

JOURNAL OF THE
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OF
CIVIL ENGINEERS

MAY, 1929

Featuring

**Development of Mongaup River
Northern Luzon Triangulation
Engine as Barometer of Air
Transport Development**



Vol. XVI

No. 5

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JOURNAL OF THE BOSTON SOCIETY OF CIVIL ENGINEERS

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THE DEVELOPMENT OF THE MONGAUP RIVER

BY WILLIAM F. UHL,* MEMBER, BOSTON SOCIETY OF CIVIL ENGINEERS

(Presented before a joint meeting of the B. S. C. E., Northeastern University Section, B. S. C. E., M. I. T. Student Chapter, Am. Soc. C. E., Harvard Engineering Society, and the Tufts Civil Engineering Society, February 20, 1929.)

THE Mongaup River rises on the southwestern slope of the Catskill Mountains in New York, and flows southerly to join the Delaware River about five miles westerly from Port Jervis. Its total drainage area amounts to about 220 square miles with a total fall of about 600 feet in the lower eighteen miles of river.

The industries and agriculture which at one time prospered on this river and the lower portions of its drainage area have gradually disappeared during the last century, although traces of old dams, mill and tannery sites, as well as scattered farm buildings, still remain.

During recent years the drainage area of the Mongaup River has almost entirely reverted to a wild and timbered state.

The distance from the lower reaches of the river to New York City is only about 60 miles, and during recent years much of the drainage area has been occupied for summer camps and for hunting and fishing clubs. Very few improved roads and no railroads exist in this territory.

Due to these conditions, it has for some time been thought that this river offered favorable hydro-electric possibilities, and in the past a number of engineering investigations have been made, having in

* Hydraulic Engineer, Chas. T. Main, Inc., Boston, Mass.

view its development for use in the New York City market which, until recently, was the only power market large enough to have justified such development. Apparently such development of a comparatively small river for a distant market could not be justified and was never undertaken for that purpose.

INCREASED DEMAND FOR ELECTRIC POWER

In the meantime the demand for electric power in the near-by cities of Port Jervis and Middletown had increased to the point where the Orange County Public Service Company, serving these cities and adjacent territory, decided to carry out a hydro-electric development at Mongaup Falls. This development was completed in 1923.

About this time the Rockland Light and Power Company, which served the territory in southern New York and northern New Jersey, west of the Hudson River and centering on Nyack, with electric light and power, acquired the Orange County Public Service Company and its ownership of water rights on the Mongaup River.

The demand for electric light and power in the combined territory of these companies indicated a sufficiently rapid growth to justify the development of the available power of the Mongaup River, provided this could be carried out economically in competition with other sources of power.

INVESTIGATIONS

A comprehensive investigation, involving surveys, borings, load studies and preliminary designs and estimates, was undertaken by Charles H. Tenney & Co., managers and engineers of the Rockland Light and Power Company, to determine the physical feasibility and economical aspects of the situation. These investigations convinced them that a plan of development could be worked out which would fit in with the growth of the company's load without increasing the cost of power to the company during the development stages beyond the cost of power from other sources, and which, upon the completion of the development, would provide the company with a source of hydro-electric power located adjacent to its market at a cost which would prove fairly attractive.

Investigations by borings and other means established the fact that except at Mongaup Falls, where a dam had already been built, no dam sites existed on the Mongaup River where such a structure could be wholly founded on rock at reasonable cost. As a matter of

fact, the number of economical dam sites were found to be few, and in order to economically develop substantially all the available head on the lower reaches of the river, it proved necessary to adapt sites for dams which were not particularly desirable from a structural standpoint.

RIVER LIES IN GLACIAL AREA

In common with other New England and New York rivers lying in the glacial area, the original Mongaup River bed is probably buried at various depths below the present river, the latter meandering back and forth across the older rock bed, but generally at a higher level on a bed of glacial drift consisting of a mixture of boulders, gravel, sand, clay and rock flour. These materials are found in both a modified and unmodified form. In a few places one bank abuts on rock and a portion or all of the bed passes over ledges, but in no case, except at Mongaup Falls, does the river run on rock between two rock banks. The rock of the Mongaup River valley consists of red and gray sandstone with occasional strata of shale. The stratification is practically horizontal, and the rock occurs in massive layers.

Borings indicated that in almost all instances the glacial overburden of the river valley is reasonably impervious. The overburden lying at higher elevations is similar to that in the valley and fairly suitable for earth fill dam construction by means of hydraulic sluicing. It contains a substantial amount of fine material with somewhat more clay in certain localities than might be desirable to obtain ideal results. Gravel beds containing a small enough sand content for economical handling and of good quality for concrete were located near every one of the proposed dams, resulting in a reasonable cost of concrete.

FIVE DAMS FOR DEVELOPMENT

The plan for developing the Mongaup River that was finally worked out, as a result of power demand studies, surveys, borings, and estimates of cost, called for the construction of four dams and power plants in addition to the Mongaup Falls power development already carried out. Two of these were combination storage and power developments.

The total head to be developed by the five dams amounts to 735 feet, and the storage made available by the two storage dams amounts to 2,800,000,000 cubic feet.

Each of the three power dams also provides a substantial amount

of pondage, so that the flow of the river can be regulated for daily and monthly variation of load as well as for seasonal variation in stream flow.

Fig. 1 shows the relative location of the Mongaup River with respect to the adjacent country, and the territory the company serves with electric light and power.

Fig. 2 shows the location of the five dams and related parts of the developments, and a profile of the lower reaches of the river, indicating the substantially complete utilization of the available head.

It will be noted that the Toronto Reservoir is on a tributary to the main river, and that the Delaware power plant is located near the bank of the Delaware River a short distance upstream from the confluence of the Mongaup and the Delaware,

The names of the developments and principal data concerning them are as follows:

PLANT	Drainage Area in Square Miles	Head in Feet	Kilowatt Capacity	Million Kilowatt- hours Yearly Output	Million Cubic Feet in Reservoir or Pond
Toronto	25	150	1,000	5	1,200
Swinging Bridge	118	125	5,000	15	1,600
Mongaup Falls	161	115	4,000	20	70
Rio	195	185	10,000	32	650
Delaware	207	160	10,000	35	100
Totals	—	735	30,000	107	3,620

A study of the company's load indicated that the demand in the immediate future would be about as follows:

YEAR	Kilowatt Peak	Kilowatt-hours Demand
1926	11,700	43,410,000
1927	13,600	49,990,000
1928	15,600	57,370,000
1929	17,900	66,090,000
1930	20,600	75,820,000
1931	23,900	87,280,000
1932	27,200	99,920,000

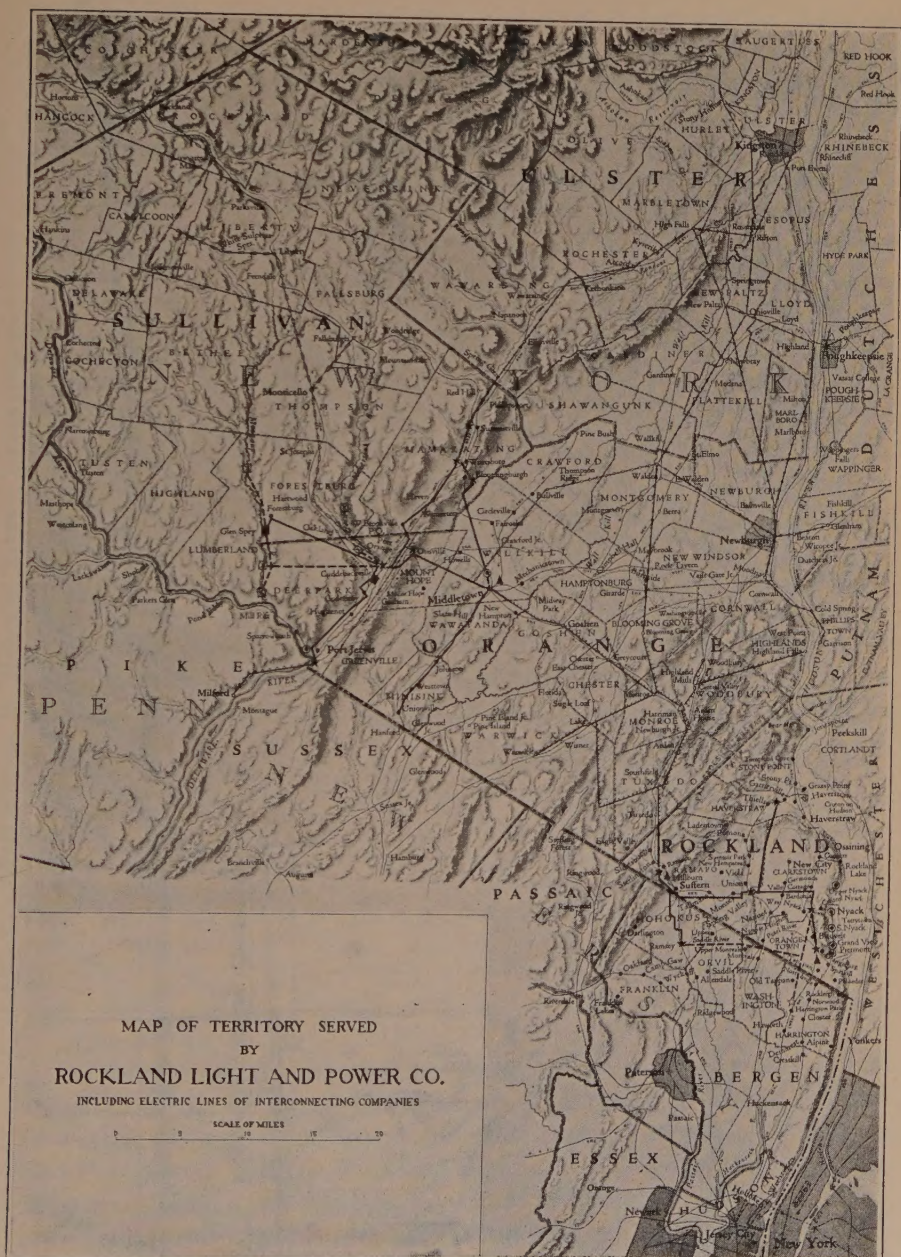


FIG. 1.—MAP OF TERRITORY SERVED BY ROCKLAND LIGHT AND POWER COMPANY

Stream flow, storage, pondage and load factor studies indicated that the four proposed developments should be planned to have an installed capacity as shown in the following table, and should be ready for operation at about the time indicated:

NAME OF DEVELOPMENT	Kilowatt Capacity	Ready for Operation
Toronto Storage	—	February 1, 1926
Mongaup Falls	1,000	February 1, 1926 (fourth unit)
Rio	10,000	November 1, 1927
Swinging Bridge	5,000	October 1, 1929
Delaware	10,000	November 1, 1931
Toronto Plant	1,000	November 1, 1932
	27,000	
Mongaup Falls	3,000	Completed in 1923
Total	30,000 Kw.	

With these developments carried out as planned, it was estimated that the system load could be supplied as follows:

YEAR .	Kilowatt-hours, Water Power	Kilowatt-hours, Steam Power	Kilowatt Steam, Peak Load
1927	24,380,000	25,610,000	8,700
1928	42,690,000	14,680,000	1,600
1929	45,180,000	20,910,000	3,900
1930	64,410,000	11,410,000	4,600
1931	71,020,000	16,260,000	5,600
1932	91,380,000	8,540,000	0

The Orange County Public Service Company, prior to its construction of the Mongaup Falls plant in 1923, supplied its requirements of electric current from two small steam plants located at Middletown and Port Jervis, and the Rockland Light and Power Company obtained its current from a steam plant located at Hillburn.

The Hillburn steam plant was reconstructed and enlarged in 1927, and with a present capacity of 15,000 Kva. it is estimated will provide sufficient stand-by service to supplement the Mongaup River hydro

developments and make the operation of the steam plants at Middletown and Port Jervis unnecessary in the future.

MONGAUP FALLS DEVELOPMENT

The Mongaup Falls development, carried out in 1922-23 by the Orange County Public Service Company, consists of a concrete spillway dam and intake built at the crest of Mongaup Falls, the only natural falls of any importance on the river. This dam is of gravity



FIG. 3. — AERIAL VIEW OF MONGAUP FALLS DEVELOPMENT

type, built on rock between rock abutments. Its height of about 40 feet with flashboards 4 feet high, creates a pond having a surface area of about 120 acres and a volume of 70,000,000 cubic feet. A total gross head of 116 feet is made available by means of the dam and a wood stave pipe line 8 feet in diameter and 2,650 feet long. (See aerial photograph, Fig. 3.)

The wood stave pipe line terminates in a simple plate steel surge tank 26 feet in diameter and 106 feet high. A short steel penstock with four successive branches leads from the surge tank to the four power units located in a power house on the bank of the river about

2,700 feet below the dam. Each of the four power units is rated to deliver 1,650 horsepower under 110 feet net head. The turbines are of the single runner, vertical, plate steel spiral type, and each is direct connected to a 1,250-Kva. vertical, 2,300-volt, 3-phase, 60-cycle generator running at 360 revolutions per minute.

Three of these units were installed in 1923, the fourth unit being installed in 1925.

The power generated in this plant is transformed to 33,000-volt current in an outdoor substation having four 1,250-Kva., 3-phase transformers and transmitted easterly into the company's territory and northerly to supply the Associated Gas and Electric Company's distribution system centering on Monticello.

TORONTO RESERVOIR

In accordance with the plan of development established from the studies previously made, the first project carried out by the present company is the Toronto Reservoir, created by a dam constructed just below the junction of Black and Toronto Lake brooks. This project was started in June, 1925, and completed about February 1, 1926, or in time to store the 1926 spring run-off, so that the Mongaup Falls plant, which up to then was a run-of-river plant, could be more fully utilized.

The Toronto dam is of the earth-fill type, constructed by the hydraulic sluicing method. Its maximum height above stream bed is 90 feet. The reservoir created by this dam floods approximately 800 acres, and will store 1,200,000,000 cubic feet. About 340,000 cubic yards of fill material were used in its construction.

Fig. 4 shows a cross section of the river at the dam site and a cross section of the dam. It will be noted that the west bank is a steep rock bank, the rock disappearing at the edge of the brook. The bed of the brook and the opposite bank consist of glacial drift which borings showed to be quite impervious.

At the site of the dam the brook made a turn which permitted the construction of a straight diversion and outlet conduit across the comparatively flat bank opposite the turn. This reinforced concrete conduit is 565 feet long from intake to outlet, and is founded on a sandy clay. It is provided with three cut-off collars at the center of the dam, and with a reinforced concrete outlet tower 150 feet downstream from the intake. The conduit is 8 by 8 feet inside, with semicircular top and walls 24 inches thick. Outlet gates are provided in the conduit under the tower

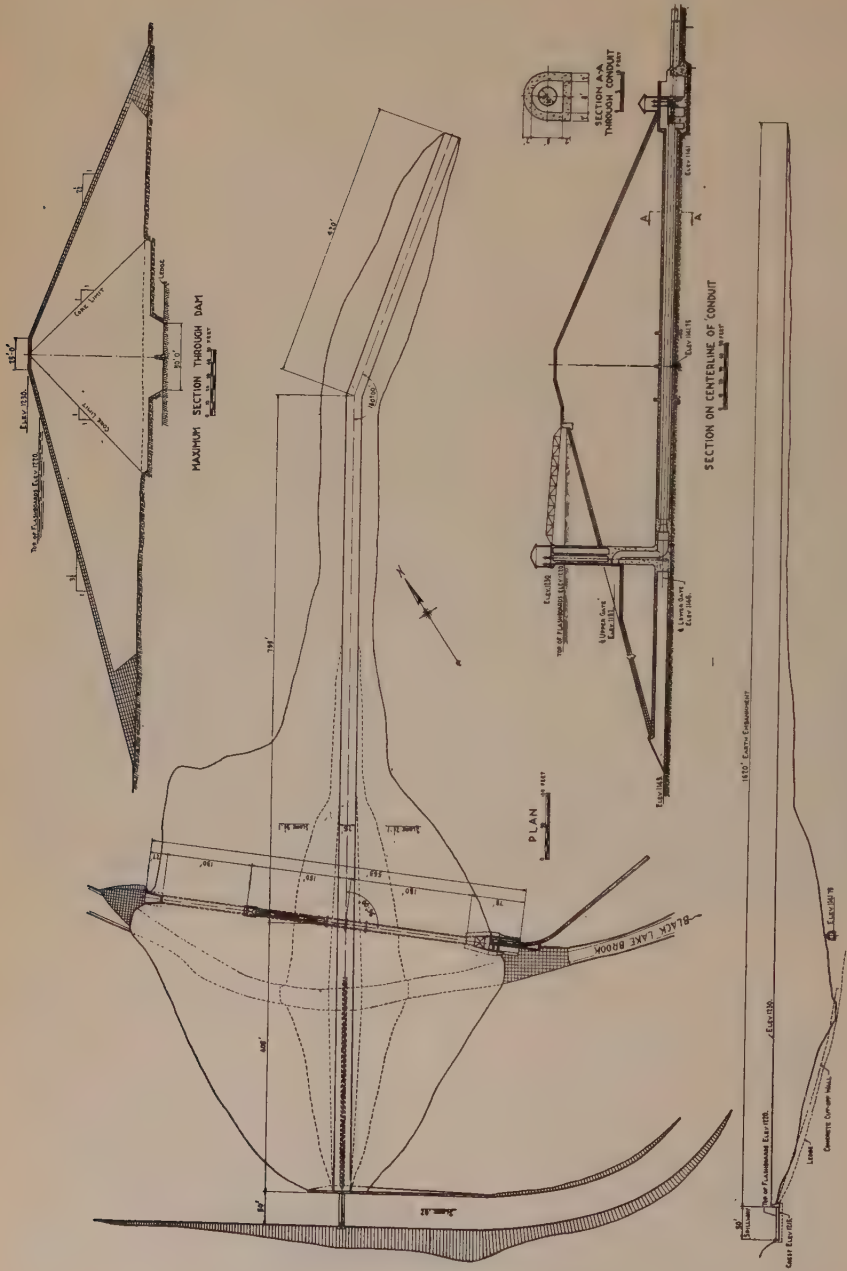


FIG. 4. — PLAN AND SECTION OF TORONTO RESERVOIR DAM

and in the tower at an elevation 40 feet below full reservoir. At the outlet of the conduit a diffuser is built which is designed to dissipate the energy of the water leaving it.

The fill for the dam was obtained from a hill beyond the dike which forms the easterly abutment of the dam. The distance from the center of the borrow pits to the center of the brook is about 2,000 feet.

The material in the pits was loosened with water discharged by hydraulic giants at about 100 pounds per square inch pressure, and transported to the dam by two lines of 20-inch diameter high carbon welded manganese steel pipes carried on trestles at an average grade of about 3.5 per cent. The 20-inch sluice pipe was put together stove-pipe fashion in 12-foot lengths. The material consisted of boulders, gravel, sand and clay, and this was deposited on the up and down stream slopes, the coarser material remaining at the edges of the slopes and the finer material being carried in suspension to a central pool, the intermediate area forming a well-graded bank varying from relatively fine material at the edge of the pool to gradually coarser towards the edges of the embankment.

The pool overflow consisted of a sectional concrete stack built up in 12-inch pre-cast sections 18 inches in internal diameter and located in the center of the pool at the inside of the diversion conduit, discharging into an 18-inch diameter pipe carried along the base of the conduit embedded in the concrete extension of the conduit base with its outlet on the side of the diffuser. Sluicing started about August 1, 1925, and continued to about January 1, 1926, after which the topping out of the dam and completion of the dike was carried on by hauling.

Before sluicing started, the site of the dam was cleared and cut-off trenches were prepared, both in the rock bank and the opposite bank, along the center line of the dam. A concrete cut-off wall was also carried along the center line of the rock trench. From 2,000 to 5,000 cubic yards of material were sluiced per 24 hours, depending upon conditions at the dam or at the borrow pits. Occasionally hardpan strata were encountered in the borrow pits, which made sluicing very difficult. At times an accumulation of boulders too large to pass through the sluice pipes would make it necessary to shift the giants or to clear portions of the pits with power shovels in order to sluice efficiently.

The pumping plant was located about 1,000 feet downstream from the dam and just upstream from a small timber diversion dam. This made it possible to use the sluicing water over, since it was feared that the natural run-off of the brook might prove insufficient during the fall months.

The pumping plant consisted of five sets of two 1,500 gallons per minute capacity horizontal centrifugal pumps in series, all discharging into a common header from which two lines of 16-inch diameter spiral riveted pipes were carried to the borrow pits about 1,700 feet distant from the pump house. Valves were provided so that any set of pumps could be shut off from the header and in the center of the header, so that the two 16-inch lines could be separated.

Each set of pumps was designed to deliver 1,500 gallons per minute against 400-foot head, so that a pressure of about 100 pounds per square inch could be obtained at the nozzles of the hydraulic giants. The size of nozzles used on the giants were 3 and 4 inch to suit the particular conditions prevailing in the borrow pits at the time. The material transported to the dam amounted to about 5 per cent of the water pumped. This would vary greatly with the slope of the sluice pipes and the nature of the material sluiced.

Power was supplied from the Mongaup Falls plant over a 33,000-volt transmission line built for this purpose, and stepped down to 2,300 volts by a substation located adjacent to the pumping plant. Three sets of pumps were direct connected to 125-horsepower motors, and two sets were equipped with 150-horsepower, 2,300-volt, 60-cycle, 3-phase induction motors.

The total power demand with the pumping plant running to capacity was about 1,350 horsepower.

The amount of power required per cubic yard of sluiced material amounted to 8.7 kilowatt-hours.

On account of the heterogeneous nature of the available fill material, it would have been very difficult to build a suitable dam at this site, in the time that it was desired to construct it, by any other than the hydraulic sluicing method. The cost of the plant used would have been large for this small dam alone, but this same plant was suitable for another similar but larger dam to be built only two years later.

The Toronto dam is provided with a side hill spillway located on the west bank of the river. It consists of a channel 50 feet wide, blasted through solid sandstone rock for a distance of about 700 feet. The rock excavation amounted to 18,500 cubic yards, and this rock was used to provide a heavy random riprap on both slopes of the dam and dikes and at both toes.

The spillway channel is designed to discharge a flood flow of 5,000 cubic feet per second, or 200 cubic feet per second per square mile of drainage area, with the water surface about 5 feet below the crest of the earth dam. Five feet of pin-type flashboards are used in the spill-

way channel. These are designed to automatically release themselves when somewhat over 2 feet of water pass over them.

The water released from Toronto Reservoir now flows into the Mongaup River about 2,500 feet south of the Swinging Bridge dam now under construction. Upon the completion of this dam it is planned to divert the Toronto Reservoir water into the Swinging Bridge Reservoir by a pipe line about 14,500 feet long and 4 feet 8 inches in diameter, at a point about three miles above the dam creating that reservoir, so that the Toronto storage may be utilized in all the plants on the river.

A 1,000 kilowatt hydro-electric unit located at the outlet of the 4-foot 8-inch pipe line will add about 5,000,000 kilowatt-hours to the yearly output of the system. It is planned to divert all of the Toronto storage into the Swinging Bridge Reservoir during the last six months of each year, and the pipe line and power unit are designed to provide sufficient capacity to accomplish this.

RIO DEVELOPMENT

Early in 1926 construction work was started on the projected Rio hydro-electric development, and this was completed in the fall of 1927.

This development, located about four miles below the Mongaup Falls power plant, consists of a gravity type concrete spillway dam with concrete and earth-fill embankment abutments, a 7,000-foot long and 11-foot diameter wood stave pipe terminating in a differential surge tank 65 feet high and 40 feet in diameter, a plate steel penstock consisting of 380 feet of 10-foot diameter pipe with a wye, and two 110-foot lengths of 7-foot diameter pipe supplying two 7,000 horsepower units located in a concrete and brick power house, a short tail-race and an outdoor step-up substation.

Fig. 5 shows the relation of the different parts of this development.

The Rio dam contains 41,400 cubic yards of concrete and about 110,000 cubic yards of earth fill.

The spillway portion of the dam, built on a sandstone ledge which crosses the river at this point and disappears at the west bank, has a height of 90 feet to the spillway crest, and is 264 feet long. It is built on a 400-foot radius curve to best fit the natural foundation. The west abutment consists of a concrete gravity type intake section 22 feet long, built on ledge, a buttressed concrete abutment wall 99 feet long, and 540 feet of earth embankment. The east abutment consists of 102 feet buttressed concrete abutment wall and 460 feet of earth-fill embankment. The total length of the dam is about 1,500 feet.

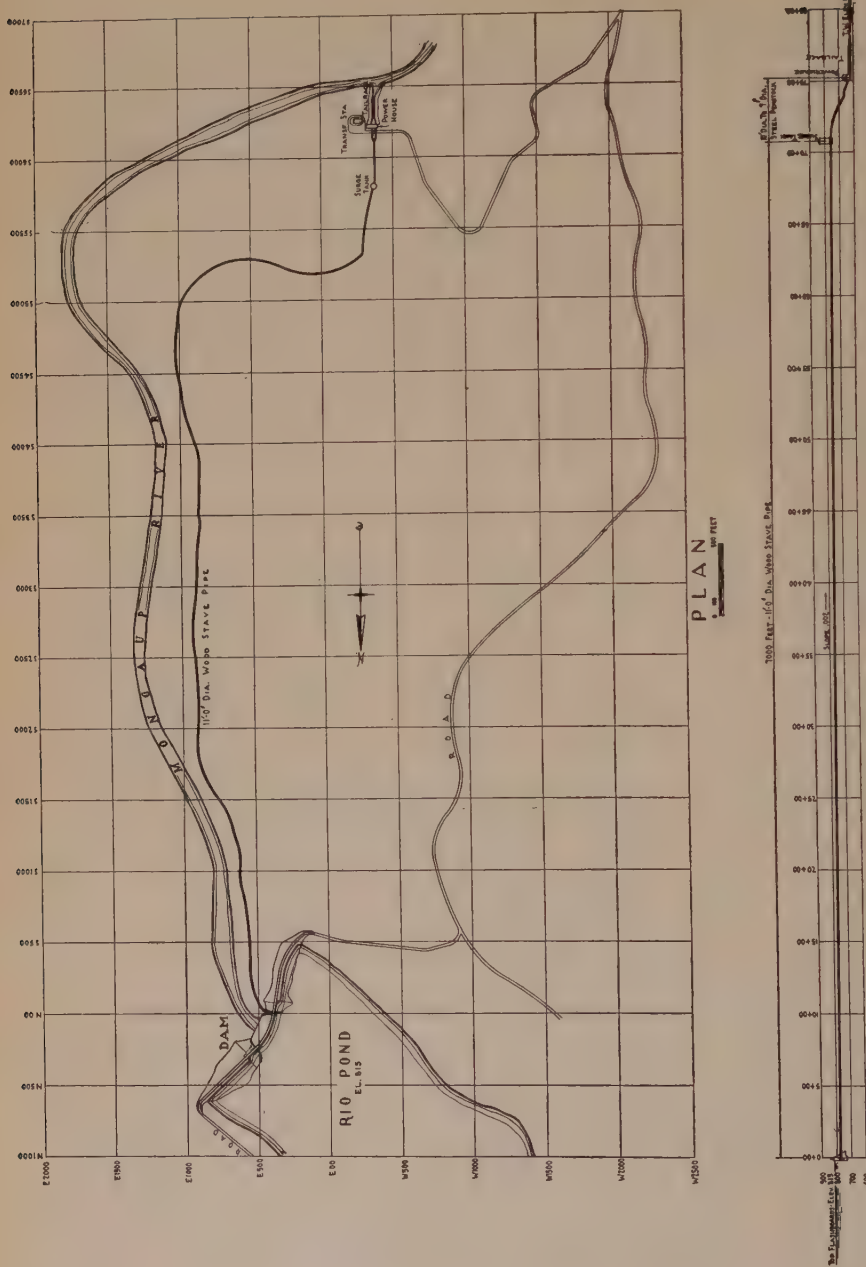


FIG. 5. — GENERAL PLAN AND PROFILE OF RIO DEVELOPMENT

The buttressed abutment walls take the place of the usual wing walls generally used where an earth fill abuts against a spillway section. The fill is carried around the abutment walls, both up and down stream, as shown in Fig. 6.

A highway is carried across the dam and abutments. The surface of this highway and of the reinforced concrete bridge over the spillway is at an elevation 15 feet above the permanent spillway crest.

The spillway is divided into eight clear openings, each 30 feet long, by the bridge piers. The bridge and roadway over the embankments leading to it have a clear width of 16 feet. It replaces a highway bridge which crossed the river about one mile upstream from the dam.

The spillway is designed to discharge a flood flow of 39,000 cubic feet per second or 200 cubic feet per second per square mile of drainage area, with a pond elevation 12 feet above the crest.

During normal stream flow conditions, 5 feet of pin-type flashboards are carried on the crest of the dam. These are so designed that they will automatically release themselves when about 3 feet of water pass over them.

The pond created by the Rio dam floods about 460 acres and contains about 650,000,000 cubic feet of water when full to the top of the flashboards.

Fig. 7 shows the dam during the construction stage.

To build the concrete portion of the dam a concrete mixing and proportioning plant was set up on the east bank of the river just upstream from the dam site.

Two 1 cubic yard tilting mixers, having a combined capacity of about 500 cubic yards per 8-hour day, were installed under the proportioning bins. These bins supplied the mixers through measuring boxes. Two inundators accurately measured the sand and regulated the water content of the mix.

The mixers discharged into 1 cubic yard side gate cars which were drawn out over a trestle behind the dam and dumped into chutes which distributed the concrete over the base of the dam as required. Later, for placing the concrete at higher levels, the cars dumped into 2 cubic yard buckets which were lifted by steel derricks conveniently placed behind the dam on each bank of the river. These buckets either deposited the concrete directly into the forms or into auxiliary hoppers from which it was taken in buggies and placed.

Both sand and stone were obtained from a gravel bed located on a flat east of the river and about one-half mile above the dam.

Aggregate was hauled by truck from the pit to a hopper placed

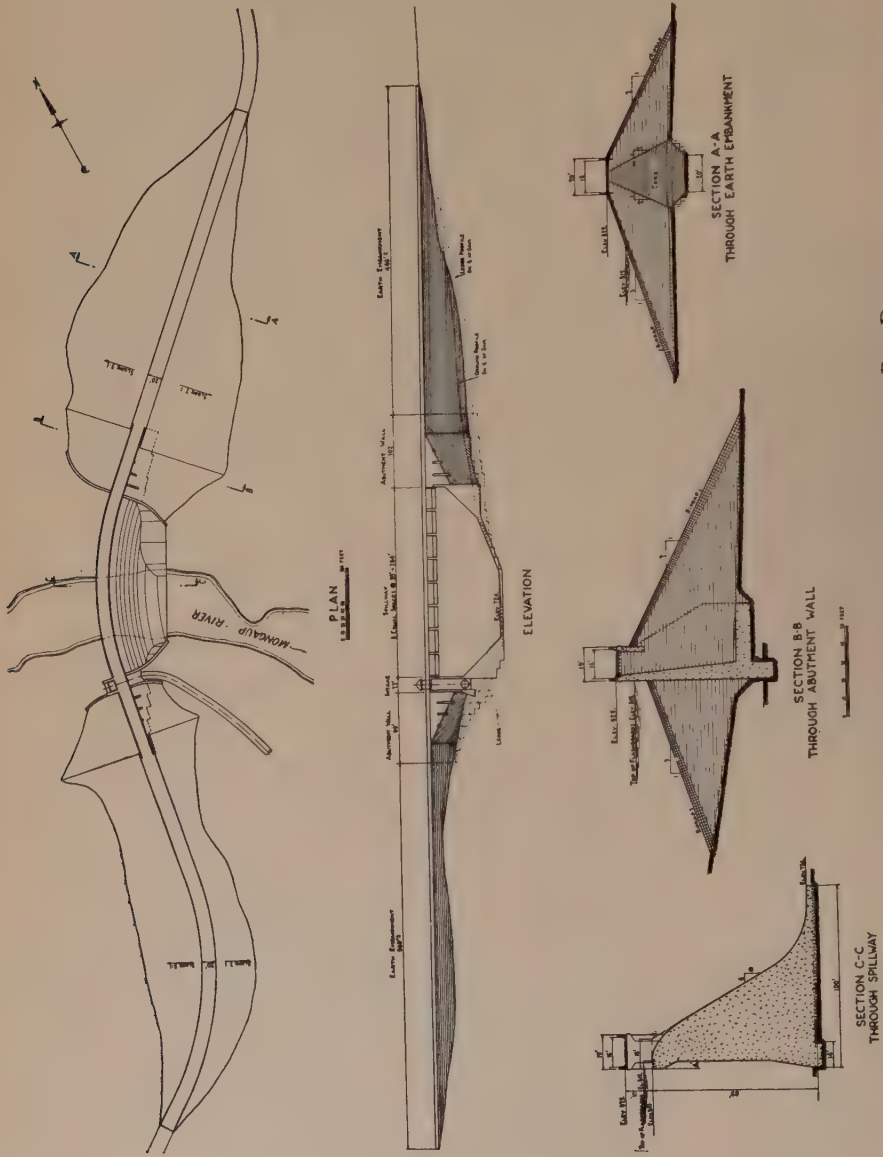


FIG. 6. — PLAN, ELEVATION AND SECTIONS OF RIO DAM

under the road, just back of the proportioning bins. Here it was fed on to a grizzly. All oversize stones were deflected and fed into a crusher.

A 40-foot bucket elevator raised the materials to a screen located above the material bins. Aggregate passing through a 4-inch screen and retained on the one-half inch screen went into the stone bins. Everything passing the one-half inch screen was classed as sand. Over-size material was wasted in piles and later used as riprap on the embankments.



FIG. 7. — PHOTO OF RIO DAM DURING CONSTRUCTION STAGE, OCTOBER 1, 1926

Water was added at the entrance of the screen to wash the aggregates, and the sand leaving the screen went through a washer before entering the bins.

While the concrete for the foundations of the east end of the spillway was being placed, a rock-filled cofferdam was built to enclose the west portion of the spillway. A 10 by 10 foot temporary sluice was left at the low point in this portion of the dam to take care of the water later on.

As soon as the west half of the spillway and the intake section on the west bank were up to a safe height, the cofferdam was taken out and a second one built across the center gap to the east section. This turned the river through the 10 by 10 foot sluice referred to above. The last stretch of the river bottom was then prepared to receive concrete, and a cut-off trench was excavated under the heel of the dam.

Just below the cut-off trench at the heel of the dam, an 8-inch drain was placed to collect any seepage water which might pass the cut-off. Cross drains, placed at 30-foot intervals, lead the seepage water collected out to the toe of the dam. This probably reduces possible uplift pressure. Some grouting was carried out just above and under the heel of the dam and abutment walls. An earth blanket was placed over the rock just upstream from the heel.

The drains were found to carry only a very small amount of seepage after the pond was filled.



FIG. 8. — PHOTO OF RIO DAM, NOVEMBER 17, 1926

By early fall of 1926 the dam was completed to the stage shown in the photograph, Fig. 8.

A 25-foot gap was left at a suitable level to help take care of the next spring freshets. After these freshets had ceased, the water was easily carried through the temporary sluice, and the 25-foot gap was then built up in the dry without difficulty.

The final step was to close the gate at the entrance to the temporary sluice and fill the hole with concrete. The spillway and intake were built of 1:3:6 mass concrete; the abutment walls, their buttresses and the mats on which they rest were built of 1:3:6 reinforced concrete; the bridge piers of 1:2.5:5 reinforced concrete; and the bridge of 1:2:4 reinforced concrete.

About 7.5 gallons of water per bag of cement were found necessary to make a workable 1:3:6 concrete, and somewhat less for the richer mixes.

The upstream face of the dam, intake and abutment walls was painted with two coats of "Inertol" to seal the pores of the concrete in order to prevent seepage of water through the dam as much as possible. The dam has proved to be a very tight structure, perhaps partly due to the "Inertol" treatment, but, it is believed, also due to the care with which the concrete was placed, its consistency, and, above all, the thorough cleaning of the construction joints.

The two earth-fill abutment embankments were built by the semi-hydraulic method, the earth fill being hauled to the up and down stream toes, and the fines sluiced into a central pool after the site was prepared, and suitable cut-off trenches dug along the center.

The intake is of simple design with a heavy timber gate covering a 9 foot 6 inch by 12 foot 6 inch opening, the top of which is 33 feet below full pond. Racks built up in sections and spaced on $3\frac{1}{4}$ -inch centers are placed in vertical slots from which they can be removed by suitable hoists and stop-logs inserted for access to the intake gate should this become desirable. It is not expected that the racks will have to be raked or that any ice difficulties will ever be experienced with the design of intake provided.

The intake gate is controlled by a single screw-stem hoist operated by motor through a set of worm and spur gears. The capacity of the hoist is 75 tons, which is sufficient to operate the gate under unbalanced conditions. A 30-inch motor-operated filler gate is also provided.

Both motors can be operated from the gate house which is provided on the intake, or from the power house about 1.5 miles distant. A water stage recorder is located in the gate house and a water stage indicator in the power house.

The 11-foot diameter pipe line leaves the intake with center line at elevation 775, or 40 feet below full pond. It begins with a sharp turn to the right, as shown in Fig. 5, made by a riveted steel curved pipe to which the wood stave pipe is connected. The wood stave pipe follows the bank of the river for a distance of about 4,000 feet, where it crosses a flat and then turns sharply to the left, the sharp turn being made by a riveted steel elbow.

The wood stave pipe is laid on a slope of 2 feet per thousand along a grade cut out of a comparatively steep bank and over a number of ravines where timber trestles are provided. A good portion of the pipe is curved, the sharpest curve having a radius of 500 feet.

The staves are 3.5 inches thick creosoted Douglas fir. The trestles supporting the pipe are also built of creosoted timber.

The trestles and pipe cradles are supported on concrete footings.

The pipe cradles are designed to be flexible to allow for the distortion of the pipe when it is empty without causing excessive local strains such as might be caused by rigid cradles. This design was worked up for this job, and is shown in Fig. 9.

The concrete footings where founded on soil are continuous reinforced concrete, and run parallel.

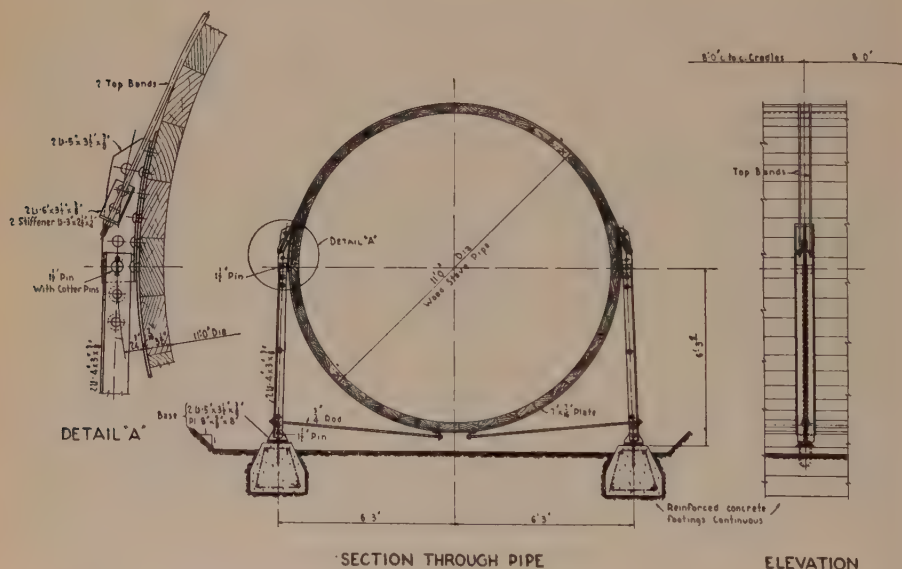
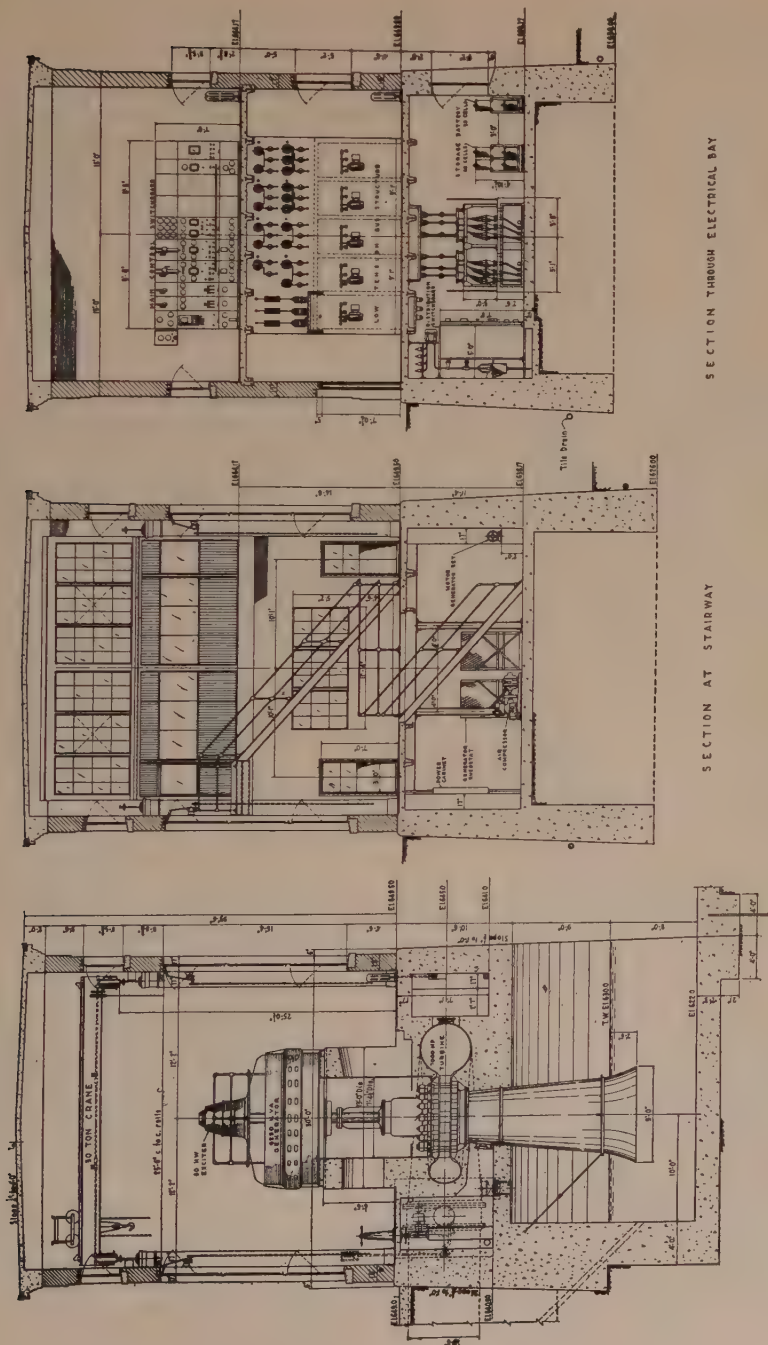


FIG. 9. — FLEXIBLE CRADLE FOR WOOD STAVE PIPE

This provides a place to haul the pipe material which would otherwise be difficult on such steep banks if cross footings were used.

The surge tank located at the end of the 7,000-foot wood stave pipe is a Johnson Differential Tank, 40 feet in diameter, 65 feet high, with an 8-foot 8-inch diameter riser. A timber frost casing covers the surge tank. The penstock connects with the wood stave pipe a short distance above the surge tank, passes under the surge tank with connections to it, and down the hill in a trench to the power house 500 feet distant.

The penstock is of riveted steel, supported by concrete anchors



SECTION ON CENTER LINE OF UNIT.
 FIG. 10. — RIO DEVELOPMENT — CROSS SECTIONS OF POWER HOUSE

at all vertical curves, and is completely covered with soil for protection against freezing.

The power house is about 30 feet wide by 81 feet long by 31 feet 6 inches high from the generator floor to the under side of the roof beams. (See Figs. 10, 11 and 12.)

The substructure of the power house is of mass concrete founded upon fine sand and clay, the superstructure of brick, and the roof reinforced concrete supported by steel beams. A 30-ton hand-operated traveling crane is provided for handling the power equipment.

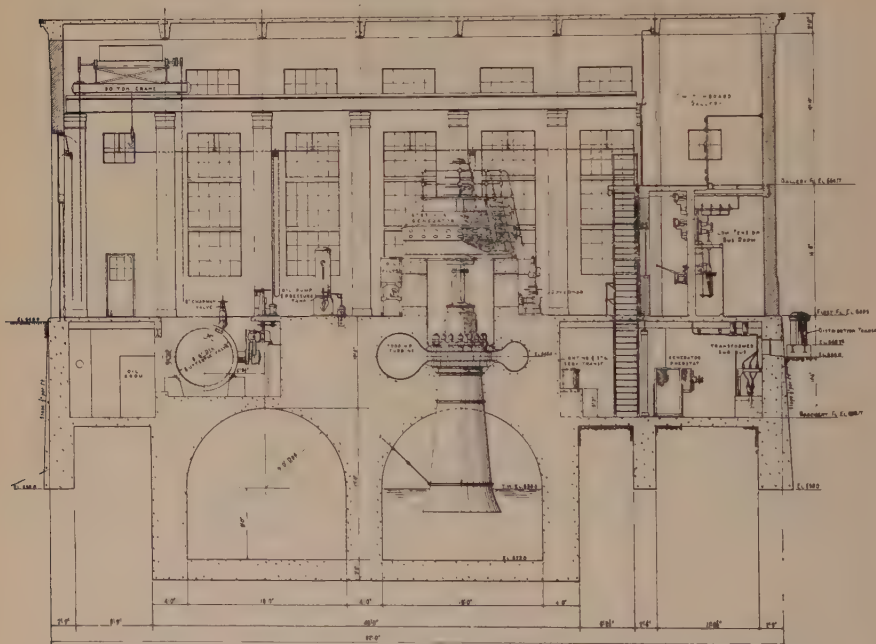


FIG. 11. — RIO DEVELOPMENT — LONGITUDINAL SECTION OF POWER HOUSE

The power house contains the hydraulic turbines, governors, control valves, generators and switchboard, together with all auxiliary equipment and the low-tension switching equipment. It is heated by an automatic oil-burning steam boiler located in a basement room at the west end of the power house.

The hydraulic machinery consists of two 7,000 horsepower single runner, plate steel spiral, vertical turbine units with plate steel conical draft tubes. The total static head is 185 feet, and the turbines are designed to deliver rated capacity under 170 feet net head at 360 revo-

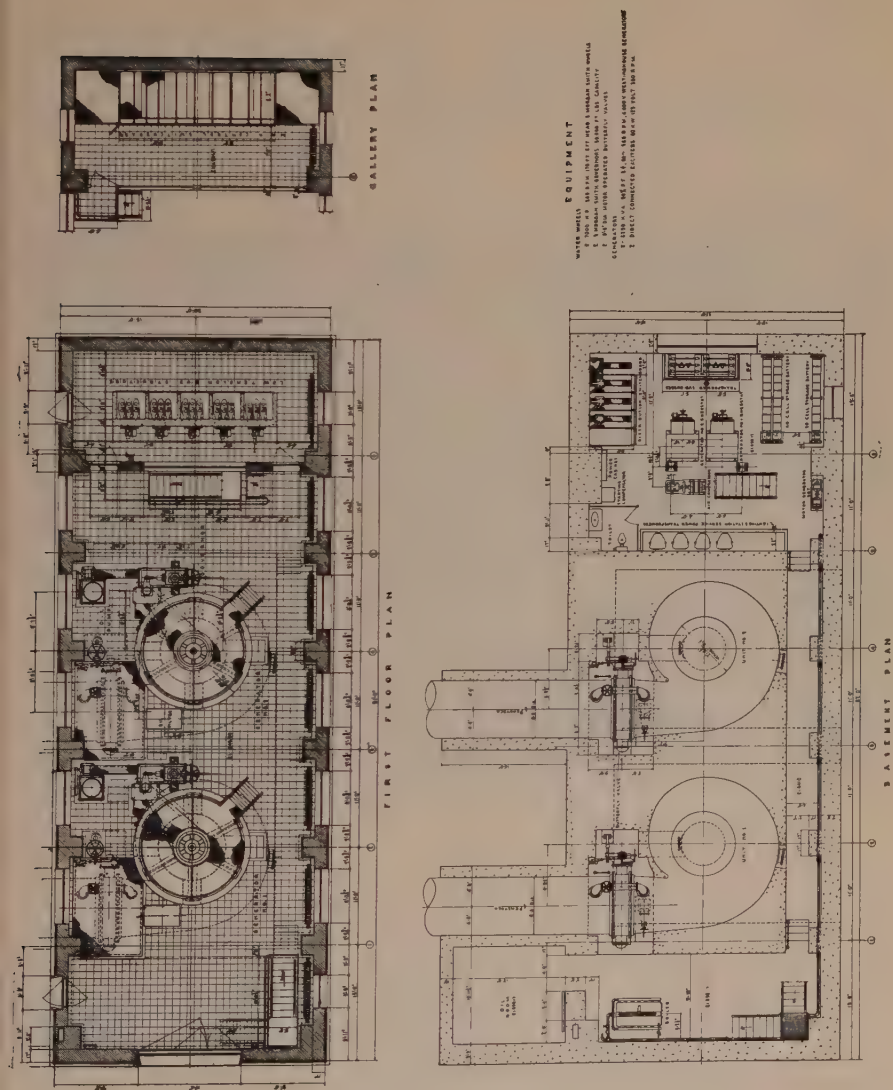


FIG. 12. — Rio Development — First Floor and Basement Plans

lutions per minute. Each turbine is controlled by an oil-pressure governor. At the inlets to the spirals, 6-foot 6-inch diameter motor operated butterfly gates are provided.

The generators are of the vertical type with direct connected excitors, and are rated at 6,250 Kva., 4,000 volts, 3 phase, 60 cycles. They are provided with amortisseur windings for self-synchronizing, and with differential protection which disconnects them from the bus in the event of failures in the armature windings.



FIG. 13.— AERIAL VIEW OF RIO DEVELOPMENT

The generators are elevated above the turbine floor by concentric concrete supports, thus eliminating the usual generator floor of the station.

The east end of the power house has three stories which house the control equipment of the development and some of the auxiliary equipment. A 60-cell storage battery provided to supply power for the operation of the oil circuit breakers and emergency lights is located on the lower of these three stories, as are the generator rheostats, a local distribution switchboard, automatic air compressor, and toilet.

The second story, which is at the main or turbine floor level, contains the low-tension oil circuit breakers which are solenoid operated

and are mounted in a concrete cell structure. These circuit breakers have a rated rupturing capacity of 16,300 amperes at 4,500 volts.

The main control switchboard of nine panels occupies the third story.

The high-tension equipment is located outdoors on a flat directly east of the power house. Two banks of three 2,000-Kva., single-phase, oil-immersed, self-cooled transformers are provided. They are operated at 4,000 volts delta to 33,000 volts delta at present, but in the future they will be operated at 66,000 volts by changing the high-tension connections from delta to wye. Four 2.5 per cent tap changers are provided above and below the normal voltage of 66,000. Expansion tanks are provided to prevent sludging of the oil, and dehydrating breathers are installed to prevent moisture entering the transformer.

The low-tension leads between the power house and the transformer station are underground cables.

Outdoor type oil circuit breakers with an air break switch by-pass are installed on the high-tension side of the transformers. These breakers are rated 400 amperes, 73,000 volts, and have a rated rupturing capacity of 4,000 amperes at 73,000 volts.

Four 66,000-volt and one 33,000-volt circuits will ultimately leave this transformer station.

SWINGING BRIDGE DEVELOPMENT

In September, 1927, the projected Swinging Bridge storage and power development was begun, and it is planned to complete this by September 1, 1929.

The dam is an earth-fill embankment built by the hydraulic sluicing method, and is located about three miles above the Mongaup Falls plant. It will have a maximum height of 135 feet and will contain about 850,000 cubic yards of fill material. Slopes will be 3.5 to 1 upstream and 2.5 to 1 downstream.

The reservoir created by this dam will be 7 miles long and will flood about 1,000 acres. It will have a storage capacity of 1,600,000,000 cubic feet and a contributing drainage area of 118 square miles.

Fig. 14 shows a cross section of the dam.

The general situation is similar to that encountered at the Toronto dam site, previously described. The west bank is steep and is formed by massive sandstone which disappears near the edge of the river, and the east bank is composed of modified glacial drift. A curve in the river at this point permitted the construction of a straight diversion

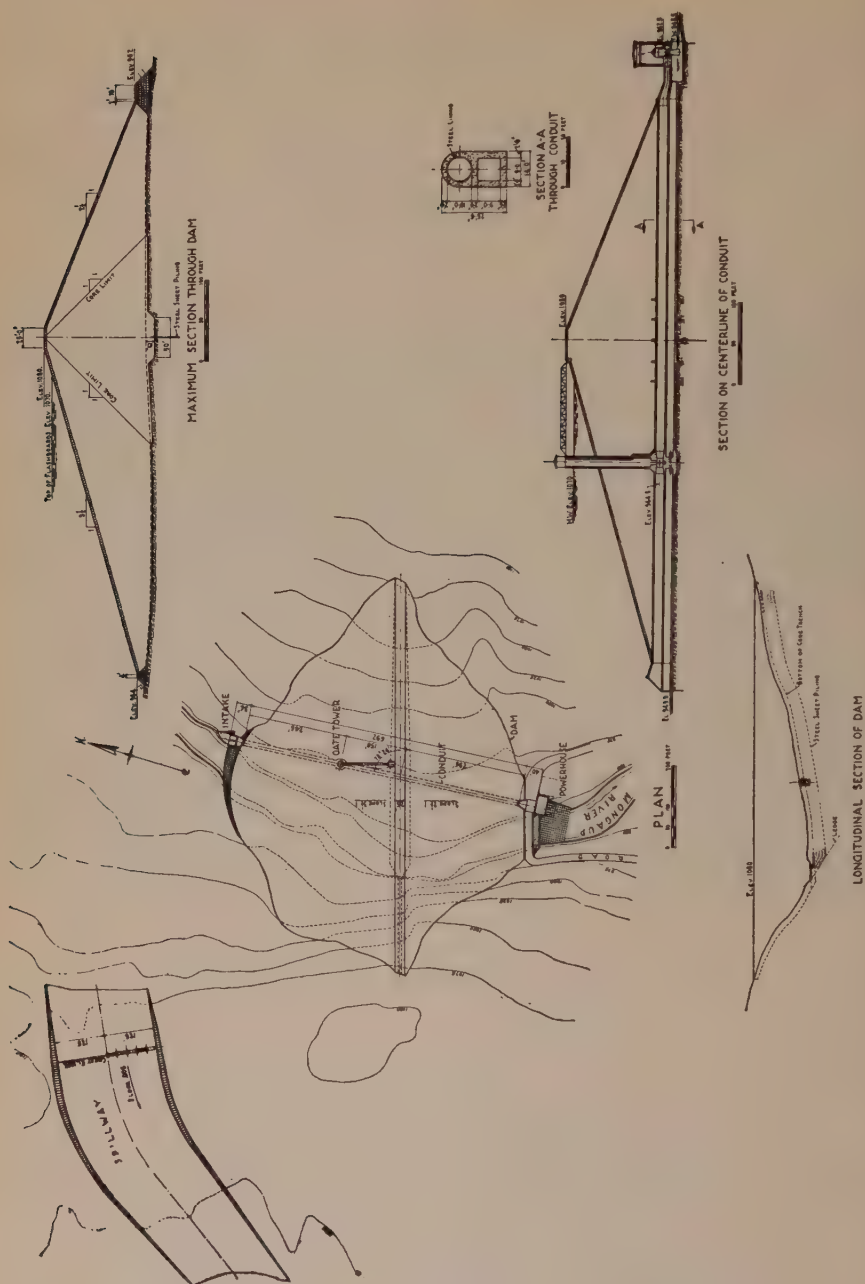


FIG. 14. — SWINGING BRIDGE DEVELOPMENT — PLAN AND SECTIONS

and outlet conduit across the east bank. This is a duplex reinforced concrete conduit about 700 feet long with an 11-foot inside diameter outlet tower located 246 feet below the intake.

The lower part of the conduit is 9 feet square. This lower conduit will be closed off after the construction is completed. The concrete closing block will be located under the tower, and on each side of it 24-inch bypass valves will be left which are accessible from the tower. The upper part of the conduit is of unlined horseshoe section 10 feet wide by 10 feet high as far as the tower, and of steel plate lines circular section 10 feet in diameter from the tower to the outlet, where it will be connected with a plate steel penstock to supply a 7,000 horsepower turbine. An 8-foot diameter motor-operated remote controlled Dow butterfly valve will be placed in the outlet tower and connected to the 10-foot diameter plate steel penstock at that point for control of the flow through the conduit.

The outlet of the duplex conduit consists of a concrete structure which will form the substructure of the power house to be built just below the dam, and in the meantime serves to dissipate the energy of the diverted water during construction. Two freshets during the past summer were in excess of any anticipated during construction, but the fill had reached a sufficient height to force the water through the two conduits without causing any serious trouble.

The spillway is located about 750 feet upstream from the dam, and will be a rock channel 250 feet wide and 650 feet long, which will discharge the waste water into Black Lake Brook, a tributary which joins the Mongaup River about 2,500 feet below the dam. The spillway sill will be at elevation 1,065.00, or 15 feet below the top of the dam. One-half the spillway width will be provided with 5 feet of pin-type flashboards designed to start bending over with about 2 feet of water passing over them. The remaining 125 feet of spillway channel will be provided with five motor-operated gates each 5 feet high by 22 feet 6 inches long. These gates are to be operated to pass freshets when the reservoir is full, to prevent the loss of the pin-type flashboards and the 5-foot depth of water behind them. The pin-type flashboards will, therefore, be lost during extreme freshets only.

The spillway channel is designed to discharge 23,600 cubic feet per second, or 200 cubic feet per second per square mile of drainage area, with 8 feet of water over the spillway sill.

The construction of the diversion conduit was completed early in 1928, at which time the work of preparing the dam site and the cut-off trench across the river bed was undertaken, the cut-off trench in the rock

on the west bank, except at the river's edge, having been completed during the winter. To prevent water passing under the sluiced core through the glacial material as much as possible, it was decided to drive 35-foot long interlocked steel sheet piling along the center line of the cut-off trench, allowing it to project a minimum of five feet above the bottom of the trench to provide a seal with the sluiced core material. At the west bank the steel piling was tied in with the rock bank by means of a concrete cut-off wall.

The rock on the west bank is massive, lying in horizontal strata



FIG. 15. — AERIAL VIEW, SHOWING CONDITION OF SWINGING BRIDGE DAM, DECEMBER 1, 1928

with numerous vertical seams. Fifty 30-foot grout holes and four 100-foot test and grout holes were put down in the rock cut-off trench. The rock proved to be tighter than expected, only a few holes taking any amount of grout, which was forced in under 100 pounds' pressure.

Sluicing was started on May 15. By December 1, when sluicing was stopped because of freezing weather, the fill in the dam amounted to 662,000 cubic yards. About 130,000 cubic yards of the total was hauled in by trucks from the spillway excavation and boulders from the sluicing borrow pits. The sluicing was carried on continuously after it was started. Fig. 15 is a photograph showing conditions about December 1.

The same pumping plant that was used to build the Toronto dam was again utilized. It was located just below the conduit outlet. The same pressure pipe and so much of the 20-inch sluice pipe as remained after completion of the Toronto operations were also used again. About 3,000 feet of additional 20-inch sluice pipe have been purchased, making a total of 7,000 feet of this pipe required for the construction of both dams. The cost of this pipe is about \$3 per foot delivered on the job. Two lines of pipe were maintained on each slope of the dam. They are supported on light timber trestles with slopes of 3 to 6 per cent. The use of two lines permits turning the pipe a few inches at a time to prevent excessive wear at one point, and shifting the trestles without interrupting sluicing operations. All of the sluiced materials are obtained from the east bank at an average distance of about 1,000 feet from the center of the embankment. The overflow from the core pool is discharged through an 18-inch inside diameter concrete stack built up with 12-inch high pre-cast concrete interlocked sections. This stack is located at the center of the pool on the west side of the diversion conduit, and discharges into the lower conduit.

The sluiced material is a glacial drift with an abundance of fines. The extremely fine material is wasted through the overflow.

Numerous test pits were dug in the borrow pit area east of the projected dam, at the time the dam site was investigated by borings, to determine the suitability of the overburden for fill by the hydraulic sluicing method. Samples taken from the test pits were screened and otherwise examined.

The following table shows the average results from screening all the samples taken. The percentage given is for materials passing the indicated screen:

Screen.	Per Cent.
No. 4	77.7
No. 10	67.4
No. 20	61.0
No. 30	54.6
No. 40	49.6
No. 50	44.7
No. 80	35.4
No. 100	32.1
No. 200	26.9

The test pits contained about 5 per cent boulders and loose native rock. The borrow pits also contained some hardpan and pockets of clay and sand.

The material was of a decidedly heterogeneous nature of glacial origin.

The solids transported through the sluice pipe amounted to about 7 per cent of the water pumped. The amount of power required per cubic yard of sluiced material amounted to 6.73 kilowatt-hours. The total cost of sluicing, including plant, is about 50 cents per cubic yard.

About 35,000 cubic yards of rock excavation will be necessary to form the spillway channel. Most of this is being placed on the up and down stream slopes of the dam to form a heavy random riprap.

The power house located just below the dam will be about 30 feet wide by 46 feet long by 32 feet 6 inches high from the floor to the roof beams. It will be a one-floor power house except for a small basement at one end of the plant, which will contain the low-tension switches, storage battery, automatic oil heater and toilet facilities. The switchboard will be located on the main floor above the basement at the end of the station.

This power house will contain one 7,000 horsepower single runner, plate steel spiral, vertical turbine, direct connected to a 6,250-Kva., 4,000-volt, 3-phase, 60-cycle, 300 revolutions per minute generator with direct connected exciter. An amortisseur winding is to be provided on the rotor of the generator to aid in self-synchronizing.

The turbine will be of special design, which provides a cylinder gate in addition to the usual wicket gates.

The switchboard equipment will provide for the manual control of the plant by an operator, as well as for the remote automatic control from the Mongaup Falls station about 3 miles distant.

The following is the sequence of operations necessary to connect the generating unit to the line automatically.

The operator at Mongaup Falls closes a control switch which opens a motor-operated valve at Swinging Bridge, allowing oil to flow under pressure to the turbine cylinder gate operating pistons, thereby raising this gate to its open position and filling the wicket gates with water.

When the cylinder gate reaches its open position, it closes a switch which energizes a solenoid on the governor pilot valve, causing the latter to operate the governor for opening the wicket gates and the unit to revolve.

When the unit reaches a speed slightly under its normal operating speed, a centrifugal switch on the top of the generator shaft closes and energizes the closing coil of the oil circuit breaker. The generator field switch now closes and the system pulls the generator into step.

The governor synchronizing motor and the load limiting device are arranged for remote control from Mongaup Falls, so that the speed of the unit and the maximum load it can carry can be adjusted from that point.

Under normal conditions of operation, this unit will carry peak loads, the Mongaup Falls plant next downstream being operated as a base load plant.

The main generator leads of the Swinging Bridge unit are connected solidly to a 3-phase transformer located outdoors adjacent to the east end of the power plant. This transformer is of 6,000-Kva. capacity of the oil-immersed, self-cooled type, and wound for 4,000 volts delta to 66,000 volts wye. A weatherproof casing is provided for housing the low-tension leads. This eliminates the necessity of using lead-covered cables with oil-filled potheads.

An oil circuit breaker on the high-tension side of the transformer will control the generator and transformer as one unit. Differential relays will protect the generator and transformer against internal faults in the windings.

A 60-cell control battery for the operation of the oil circuit breaker, automatic equipment and emergency lights is provided and located in the power house basement.

A single circuit, 66,000-volt transmission line will connect this station with the central switching station at Mongaup Falls.

The design and purpose of the combination cylinder and wicket gate turbine provided for the Swinging Bridge plant may be of interest.

Fig. 16 shows a vertical half section through the turbine and the relative location and design of the speed ring, cover plate, cylinder and wicket gates. It will be noted that the cylinder gate is located just outside of the wicket gates, with a slot for the cylinder gate between the speed ring and cover plate. The cylinder gate is operated by oil-pressure pistons, the oil pressure being obtained from the governor oil-pressure system.

This cylinder gate permits keeping the spiral full of water when the unit is shut down, without an excessive loss of water by leakage, as would occur if the wicket gates were used for this purpose. The unit being primarily a peak load unit, it will probably be shut down at least 50 per cent of the time.

If the spiral is kept full of water, no time will be lost when starting the unit in filling the penstock or the spiral, as would be the case if the butterfly gate in the outlet tower were used, or a butterfly gate at the spiral intake were provided and closed whenever the unit is shut down.

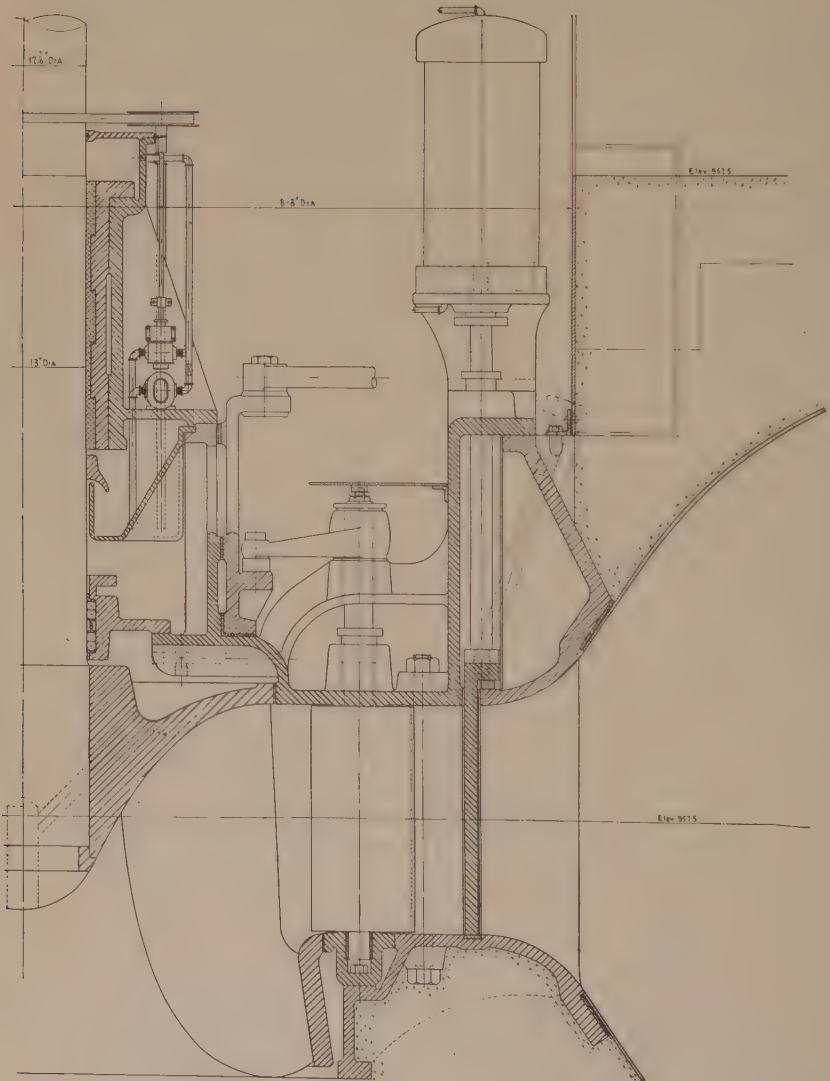


FIG. 16. — VERTICAL HALF SECTION OF TURBINE

DELAWARE DEVELOPMENT

It is expected that construction work on the projected Delaware development will be started early in 1930, and that it will be ready for operation in the early fall of 1931.

Fig. 17 shows the relation of the different parts of this development.

The dam site is located about a mile below the Rio power plant. The spillway crest will be at elevation 630.00, or about the same as the normal operating tail-water in the Rio tailrace. The Delaware power house will

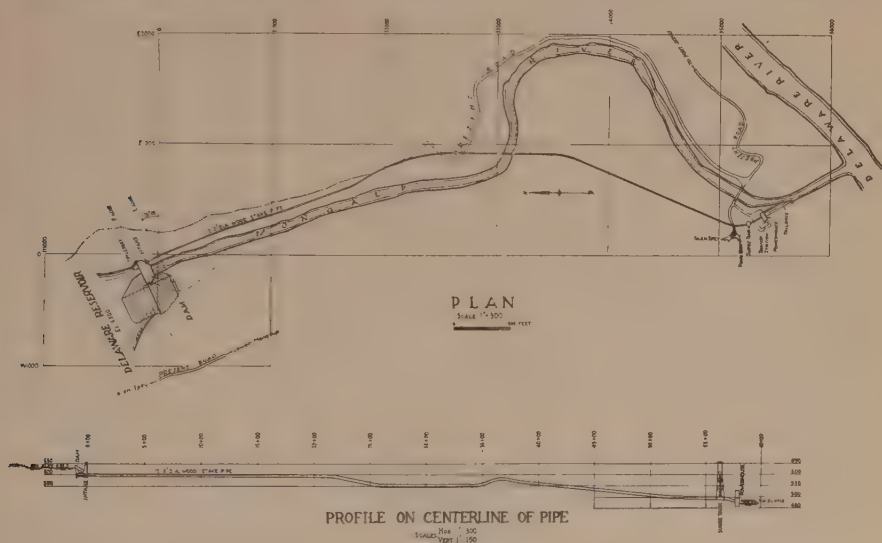


FIG. 17. — DELAWARE DEVELOPMENT — GENERAL PLAN

be located on the west bank of the Mongaup River about 1,000 feet upstream from the confluence of the Mongaup with the Delaware.

The natural fall in the lower 1,000 feet of the Mongaup River is about 15 feet. This section of the river will be excavated to such depth and cross section that it will serve as a tailrace between the power plant and the Delaware River, fully utilizing the available fall in the Mongaup at this point.

The total gross head developed will be 160 feet.

A 12-foot diameter wood stave pipe line, 5,600 feet long, will connect the intake at the dam with a differential surge tank located a short distance upstream from the power house. The surge tank will be supported on an elevated structure, and will be 45 feet in diameter by 55 feet high.

A riveted plate steel penstock joins the wood stave pipe a short distance above the surge tank, passes under the surge tank with connections to it, and to the power house about 120 feet from the surge tank. This penstock will be 11 feet in diameter with two branches, each 7 feet 6 inches in diameter leading to two 7,000 horsepower turbines.

The dam will be 510 feet long. About one-half of it will be a concrete spillway and the other one-half will consist of an earth embankment.

Sandstone ledge is exposed on the east bank and nearly halfway across the bed of the river, where it suddenly disappears.

The spillway will be 220 feet long, and this portion of the dam will have a height of 80 feet. The embankment section will be 80 feet high, with an upstream slope of 3.5 to 1, and a downstream slope of 2.5 to 1. It is planned to place the fill by the semi-hydraulic method after preparing a suitable cut-off trench under the core. Interlocked steel sheet piling will probably be driven in the core trench in an attempt to reduce underseepage, as the borings indicate that the foundation material at this point is probably not as impervious as desirable. The earth embankment will be provided with rock-fill toes and heavy random riprap on both slopes. The dam and intake will contain about 22,500 cubic yards of concrete and about 200,000 cubic yards fill.

To increase the length of the spillway as much as possible without excessive cost, it was decided to locate the intake structure below the dam at the east bank. A pipe is carried through the dam to the intake tower, where the racks, intake gates and hoists are located. The details of this will be similar to the Rio intake.

The pond created by the Delaware dam floods about 150 acres, and will contain about 100,000,000 cubic feet of water.

The pipe line will follow the east bank of the river for a distance of about 3,000 feet, where it will cross to the west bank on a trestle across a curve in the river. From this point it will be carried across a flat area in a nearly direct line to the surge tank located about 1,500 feet from the Delaware River. The wood stave pipe line will be carried in flexible cradles supported on concrete footings similar to those used for the Rio pipe line.

Except for the spillway portion of the dam, the intake and a short section of the pipe line below the dam, all structures, including the power house, will have to be founded on glacial drift.

The power house to be located on the west bank of the Mongaup River will have a concrete substructure and a brick superstructure and

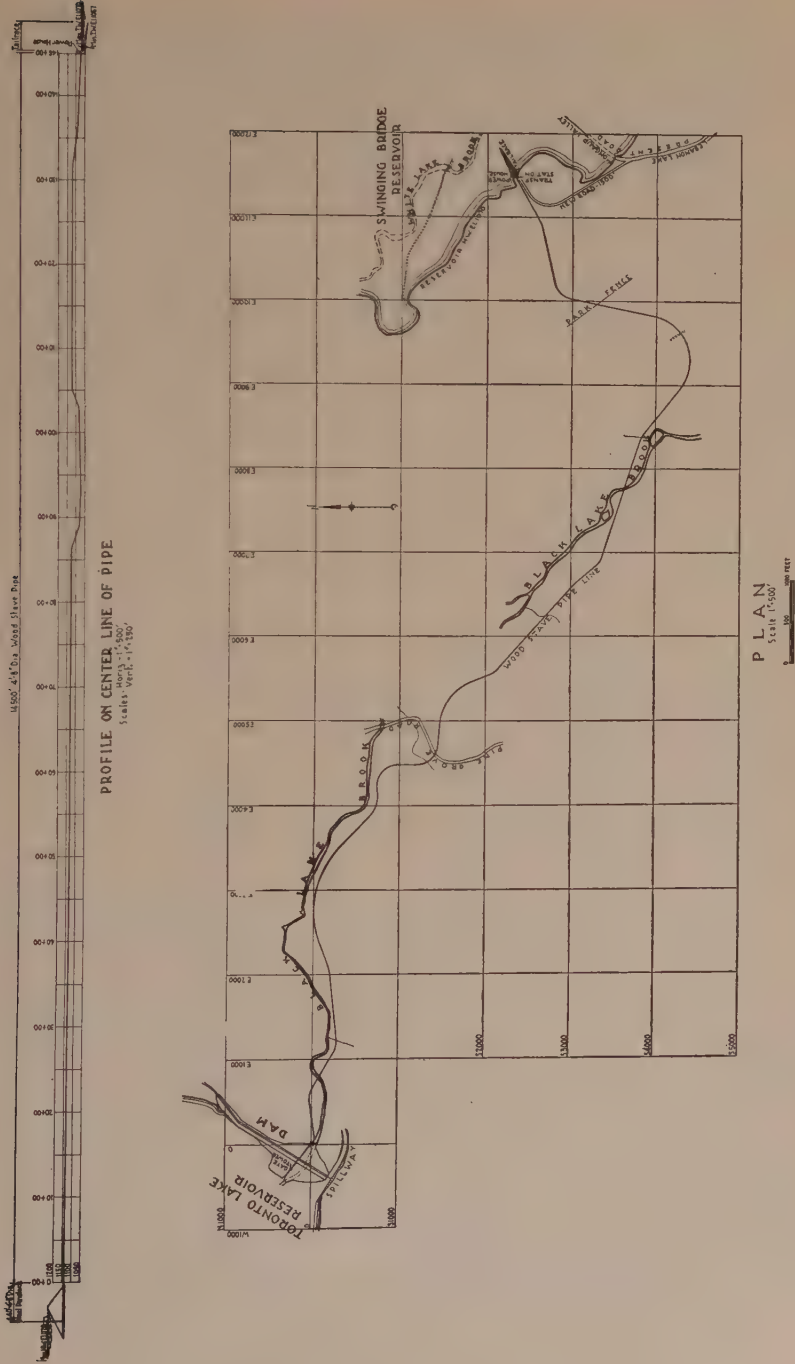


FIG. 18. — TORONTO PIPE LINE DEVELOPMENT — GENERAL PLAN AND PROFILE

will be a two-story structure. The two 7,000 horsepower turbines with butterfly gates, and some of the auxiliary equipment, will be located in the basement. The turbines will be of the single runner, vertical, plate steel spiral case type, with curved concrete draft tubes, and they will be direct connected to 6,250 Kva., 300 revolutions per minute vertical generators with direct connected excitors. The generator floor elevation is planned to be well above possible high water in the Delaware River. The step-up substation will be located just west of the power house at the same elevation as the generator floor. It will contain two 6,000-Kva., 3-phase, 4,000 to 66,000 volt transformers with the necessary switching equipment and other auxiliary apparatus for two outgoing circuits. No low-tension switching equipment will be provided, all switching being provided for on the high-tension side of the installation.

While the Delaware development is being made, or shortly thereafter, it is planned to complete the full projected development of the Mongaup River by the diversion of the Toronto Reservoir storage into Swinging Bridge Reservoir as previously mentioned.

The difference in elevation between the two reservoirs when both are full is 150 feet.

It is planned to build a pipe line between these two reservoirs, leading to a power plant on the westerly edge of Swinging Bridge Reservoir at a point about 2.5 miles upstream from the Swinging Bridge dam, thus making it possible to utilize the Toronto Reservoir storage, first under the head between these two reservoirs, and secondly under the head of the Swinging Bridge plant.

Fig. 18 shows the relative location of the various parts of the development.

On account of the large capacity of the Toronto Reservoir in comparison to the drainage area contributing its run-off to it, it is practicable to conserve this storage and draw it into Swinging Bridge Reservoir through a connecting pipe line and power plant during the low-water season, or usually during the last six months of the year, provided the pipe line and power unit are made sufficiently large to do this.

This plan requires a pipe line 4 feet 8 inches in diameter and 14,500 feet long, and a power plant having a capacity to use about 100 cubic feet per second under the minimum head that will exist. This will be about 100 feet.

This development will add about 5,000,000 kilowatt-hours to the output of the system, about one-half of this being generated at the pipe line plant and the other half in the Swinging Bridge plant. Since this output will be generated during the dry season, it will materially

increase the prime water power of the system. It will also help to sustain the capacity of the Swinging Bridge plant, since the head on this plant, which is a storage plant with a variable head, will be sustained due to the incoming water from Toronto Reservoir.

Another important advantage that will result, due to this development, lies in the simplification of the control of storage water for use at the Mongaup Falls plant, and to some extent in the Rio and Delaware plants downstream.

If the Toronto pipe line were not built, it would be necessary to strike a careful balance between the water released from the Toronto Reservoir via Black Lake Brook, and the water released from the Swinging Bridge Reservoir through the power unit at the outlet of this reservoir, in order not to either waste water or head at Mongaup Falls.

It will also be possible to keep the water in the Mongaup Falls pond at a higher elevation if all storage water is released at one point, namely, the Swinging Bridge plant, without danger of waste in case of rains on the drainage area intervening between the two storage dams and the Mongaup Falls pond.

The pipe line between Toronto and Swinging Bridge reservoirs will consist of 450 feet of 4-foot 8-inch diameter plate steel pipe and 14,250 feet of 4-foot 8-inch diameter wood stave pipe. The steel pipe will be carried into the outlet tunnel of the reservoir to a point just downstream of the gate tower, and there its intake will be formed in a concrete block poured in the tunnel. At the diffuser, which is located at the outlet of the tunnel, a wye branch with a valve will be located so that in the future, in case of emergency, water can be discharged into Black Lake Brook and allowed to flow downstream as it now does.

At this point a valve will also be placed in the 4-foot 8-inch pipe, so that the water can be shut off here in case of trouble on the wood stave pipe at any time.

The plate steel pipe will extend down the easterly bank of Black Lake Brook to just above the point where the spillway channel on the opposite bank joins the brook. From this point the wood stave pipe will be built. The wood stave pipe will cross Black Lake Brook twice; once about 850 feet below Toronto dam outlet, where the pipe line will cross to the west bank, and a second time about 9,000 feet below the dam, where the pipe will cross back to the east bank in the form of an inverted siphon. These crossings will be on timber trestles.

The power plant will consist of a concrete substructure and brick superstructure. It will house a single runner, vertical, spiral case tur-

bine, having a capacity of 1,350 horsepower at 140-foot head and 900 horsepower at 90-foot head, direct connected to a 1,125-Kva. vertical generator, 3-phase, 60-cycle, 2,400-volt, at 600 revolutions per minute, with direct connected exciter. The turbine will be provided with a motor-operated butterfly gate at the spiral entrance. A by-pass valve will be provided just upstream from the butterfly gate, to permit discharging water into Swinging Bridge Reservoir in case the power unit is out of service.

A switchboard and electric control equipment will also be located in the power plant, as well as an oil-pressure turbine governor.

The power generated will be stepped up to 66,000 volts in an outdoor transformer station located adjacent to the power plant and carried to the Swinging Bridge plant over 2.5 miles of 66,000-volt transmission line.

It is planned to run the unit continuously at a fixed gate opening without attendance.

The governor will be adjusted to operate against a load-limit device fixed to suit the head on the plant at any time and changed periodically as the head varies. It is estimated that a monthly adjustment will be all that is necessary. In case of loss of load due to line trouble, the governor will close the wheel gates and shut the unit down until an operator visits the plant and again synchronizes the unit with the system.

Under average conditions, it is estimated that this plant will operate from July 1 to January 1 and be closed down the other six months in each year.

PERSONNEL

The entire work is being carried out under the supervision of Mr. F. C. Sargent, vice-president in charge of engineering, for Charles H. Tenney & Co. He also conducted all negotiations connected with the purchase or condemnation of lands and flowage rights, the closing or relocation of highways and bridges, relocation of telephone and oil pipe lines, cemeteries, etc.

R. S. Greig of Charles H. Tenney & Co. has been in charge of the preliminary field work, consisting of surveys, borings, test pits, etc.

The designs and specifications were prepared by Chas. T. Main, Inc., under the writer's direction, in co-operation with the engineering staff of Charles H. Tenney & Co.

Mason T. Whiting, L. G. Ropes and E. M. Wilbur have acted as resident engineers on various parts of the work.

The construction work has been carried out by Fred T. Ley & Co., Inc., under Angelo Morris as superintendent.

The electric equipment for the Mongaup Falls plant is of General Electric Company's make. The Rio plant equipment was provided by the Westinghouse Electric and Manufacturing Company. The generator and transformer for the Swinging Bridge plant will be provided by the Allis-Chalmers Manufacturing Company, and the switchboard and switching equipment by the Westinghouse Electric and Manufacturing Company. The hydraulic equipment for all three plants is of S. Morgan Smith Company make.

The wood stave pipes for the Mongaup Falls and Rio developments were furnished and erected by the Continental Pipe Manufacturing Company.

The penstock, steel bends and flexible cradles for the Rio development were furnished and erected by the Walsh Holyoke Steam Boiler Works.

The Rio differential surge tank and the Swinging Bridge penstock were furnished and erected by the Petroleum Iron Works Company.

The pumping units, both pumps and motors, for hydraulic sluicing, are of Allis-Chalmers Manufacturing Company make. The 20-inch high carbon manganese steel sluicing pipe was supplied by the American Rolling Mill Company.

The spiral riveted pressure pipe and hydraulic giants were supplied by Abendroth & Root Manufacturing Company.

ANALYSIS OF CORE MATERIALS*

SWINGING BRIDGE DEVELOPMENT

MAXIMUM SIZE OF PARTICLE IN MM.	PER CENT FINER FOR SAMPLES AS NUMBERED.											
	No. 10 El. 949	No. 44 El. 964	No. 51 El. 969	No. 68 El. 985	No. 74 El. 989	No. 76 El. 990	No. 79 El. 991	No. 90 El. 993	No. 84 El. 993	No. 94 El. 1002	No. 97 El. 1002	No. 105 El. 1008
.930	—	—	—	—	100	—	100	100	—	100	—	—
.460	—	—	100	—	94	—	95	98	—	97	—	—
.300	—	100	98	—	83	—	93	97	—	95	—	100
.200	—	89	96	—	47	—	88	94	100	90	—	99
.160	—	84	94	—	42	100	85	90	99	88	100	89
.120	100	69	86	100	31	99	73	77	95	85	99	79
.080	98	55	79	99	28	92	63	72	91	82	97	69
.050	91	38	72	96	25	73	52	63	86	78	92	61
.032	81	19	69	78	20	70	45	58	79	75	82	59
.024	59	15	57	66	15	63	36	48	59	60	71	52
.016	49	12	35	54	11	50	25	38	34	35	61	47
.008	14	10	23	42	7	30	16	20	25	21	32	26
.004	10	4	12	20	3	5	10	7	12	8	10	11
.002	5	1	2	2	1	2	4	1	2	1	2	2
Effective size	.004	.008	.004	.003	.014	.005	.004	.005	.004	.005	.004	.004
Uniformity coefficient	6	12	6.5	7	17	4.4	17.5	8	6	5	4	10

* Not in original paper. Core samples were submitted by E. M. Wilbur, Resident Engineer, and analyzed by Mr. C. W. Robinson, of Chas. T. Main, Inc.

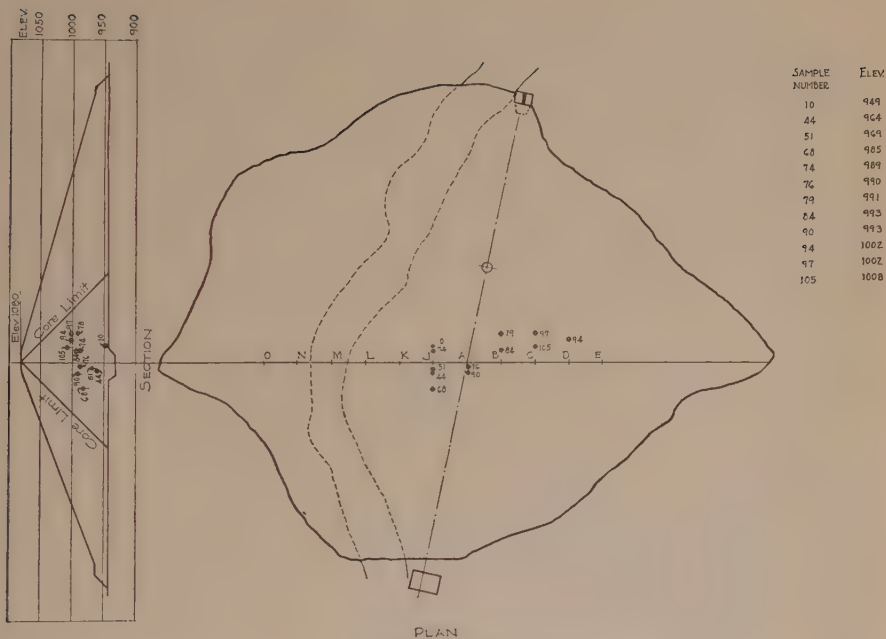


FIG. 19. — SWINGING BRIDGE DEVELOPMENT — PLAN SHOWING LOCATION OF CORE SAMPLES

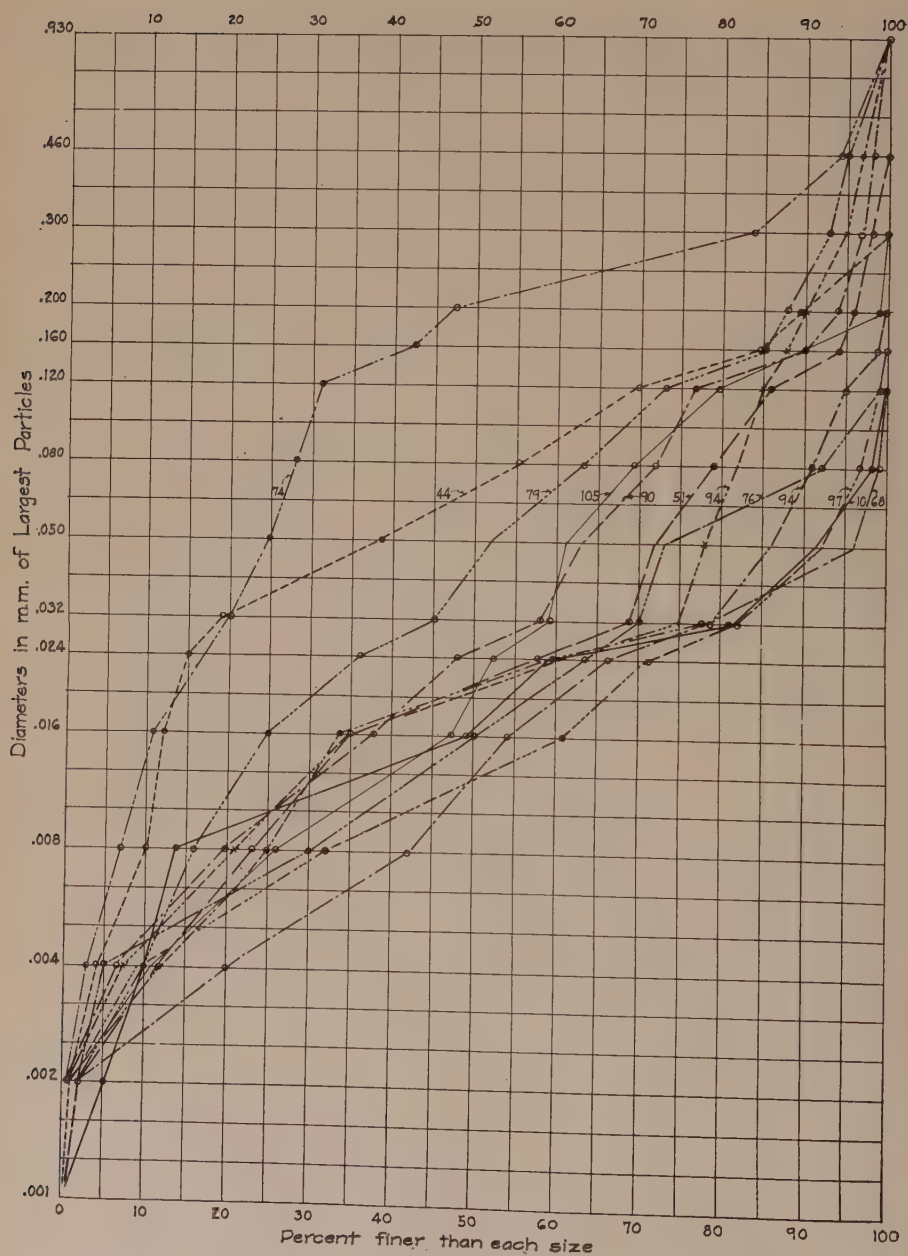


FIG. 20. — SWINGING BRIDGE DEVELOPMENT — ANALYSIS OF CORE MATERIALS

Discussion

PROF. H. K. BARROWS:* The speaker would first like to express a word of appreciation of the excellent paper presented by Mr. Uhl. It is one that has not only been of much interest in its presentation, but will also be of great value to study and consult when published in the JOURNAL.

Available Power. — Several precipitation records are available in the general vicinity of the Mongaup River. No records of run-off have been kept on the river itself. This seems unusual in view of the importance of the stream for power development, and presents an argument in favor of extending the excellent work of stream gaging now being carried on by the United States Geological Survey.

To estimate the probable yield of the Mongaup River it is therefore necessary to utilize records of flow on other near-by streams. In Table I are compiled such data of precipitation and run-off as seem applicable to the situation. (See also Fig. 21.)

TABLE I. — PRECIPITATION AND RUN-OFF — MONGAUP RIVER

YEARS	MEAN YEARLY PRECIPITATION (INCHES)		MEAN YEARLY RUN-OFF (INCHES)			
	Port Jervis	Jefferson- ville	Beaverkill (236 Square Miles)	East Branch, Delaware (785 Square Miles)	West Branch, Delaware (611 Square Miles)	Rondout (100 Square Miles)
1919-20 . . .	56.24	53.04	36.26	34.80	25.72	32.60
1918-19 . . .	41.06	40.00	28.96	26.25	20.30	28.30
1917-18 . . .	42.10	37.97	28.37	25.63	24.10	25.10
1916-17 . . .	32.10	40.41	35.28	28.96	26.09	29.50
1915-16 . . .	45.96	43.56	36.26	32.46	28.59	38.10
1914-15 . . .	41.55	40.22	30.83	28.23	19.48	29.90
Mean . . .	43.17	42.50	32.67	29.40	24.04	30.60

* Professor of Hydraulic Engineering, Massachusetts Institute of Technology, and Consulting Engineer.

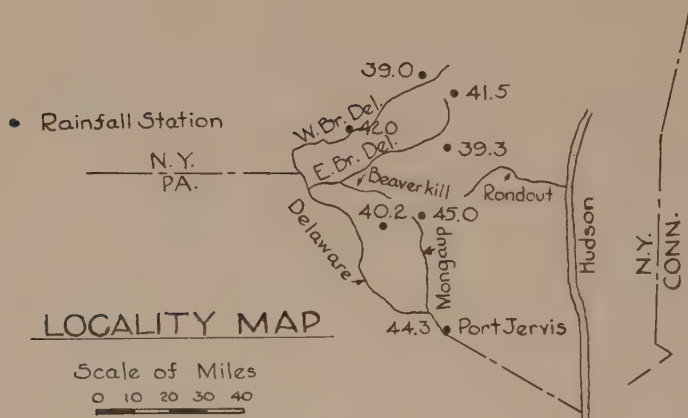


FIG. 21. — PRECIPITATION

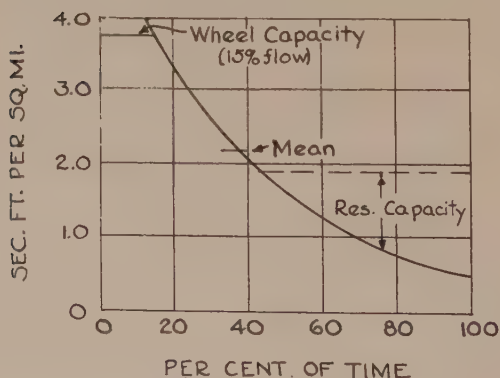
FLOW-DURATION CURVEBased on $\log. Q = 2.40 - 0.011 T$ Mean Yearly $Q = 30^{\text{in}} = 2.20$ sec. ft. per sq. mi.Mean Q (to 15% flow) = 1.81 sec. ft. per sq. mi.

FIG. 22. — DURATION CURVE

The yearly run-off in this vicinity is unusually high, and it is likely that the precipitation records do not fairly represent the general situation.

A mean yearly run-off of 30 inches, or 2.2 second feet per square mile of drainage area, appears to be available without question.

To determine the variation in yearly run-off based upon the mean flow, an excellent approximate method involving little computation is afforded by the Heyser formula:

$$\text{Log } Q = 2.40 - .011 T$$

where Q is discharge expressed as a per cent of the mean, and T is per cent of time. This formula was deduced by Mr. A. S. Heyser, M. I. T., 1926, in a thesis investigation under the direction of the speaker, and applies with little error to streams here in the East.

In Fig. 22 is shown a flow duration curve based upon the Heyser formula, and a mean flow of 2.2 second feet per square mile.

Based upon Fig. 1 and data in Mr. Uhl's paper, Table II has been prepared showing available power, etc.:

TABLE II. — AVAILABLE POWER, ETC. — MONGAUP RIVER

PLANT	Head (Feet)	Drainage Area (Square Miles)	Mean Discharge (Second Feet)	WHEEL CAPACITY			POWER IN AVERAGE YEAR	
				Second Feet	Second Feet (Square Miles)	Flow Per Cent of Time	Kilowatts	Million Kilowatt- hours Yearly
Toronto	150	25	45	98	3.90	13	650	4
Swinging Bridge	125	118	214	580	4.90	7	1,820	16
Mongaup	115	161	292	510	3.17	23	2,280	20
Rio	185	195	352	780	4.00	12	4,400	38
Delaware	165	207	375	881	4.25	20	4,200	37
Total	740	—	—	—	4.04	15	13,350	115

The relative storage facilities on Mongaup River are shown in Table III:

TABLE III. — MONGAUP RIVER STORAGE

PLANT	STORAGE CAPACITY			Head below Storage (Feet)
	Million Cubic Feet	Million Cubic Feet per Square Mile	Inches	
Toronto	1,200	48.0	20.7	740
Swinging Bridge	1,600	23.7	10.2	590
Mongaup	70	17.5	7.6	465
Rio	650	14.1	6.1	350
Delaware	100	13.5	5.8	165
Total	3,620	17.5	7.6	560

There is evidently sufficient storage to largely regulate the flow of Mongaup River. Considering the entire amount of 3,620 million cubic feet on the entire drainage area of 207 square miles, or 17.5 million cubic feet per square mile, this would, if used without any waste, bring the minimum flow up to about 1.9 second feet per square mile, as shown on Fig. 2. Assuming 75 per cent of the reservoir capacity used during the average year, the minimum flow would be about 1.65 second feet per square mile, or the primary power can be kept up to about 90 per cent of the average available up to the 15 per cent flow. This is fairly consistent with Mr. Uhl's forecast for 1932 of about 91 million kilowatt-hours of water power, with some allowance for waste and losses.

Penstock Velocities. — Table IV gives a summary of penstock velocities, etc., for the Mongaup River plants:

TABLE IV. — PENSTOCK VELOCITIES, ETC. — MONGAUP RIVER

PLANT	Head (Feet)	WHEEL CAPACITY (SECOND FEET)		PENSTOCK			$\frac{V}{\sqrt{2gh}}$	$\frac{V}{\sqrt{2gh}}$ (Full Gate)	Esti- mated Loss of Head (Feet)	h_f Per Cent of h
		Full Gate	40 Per Cent Ca- pacity	Di- ameter (Feet)	Length (Feet)	Area (Square Feet)				
Toronto	130 ±	98	39	4.67	14,500	17	92	0.06	25	19
Swinging Bridge	125	585	235	10 ±	700	78	90	0.08	1	1
Mongaup	115	510	204	8	2,650	50	86	0.12	7	6
Rio	185	800	320	11	7,000	95	109	0.08	9	5
Delaware	165	890	356	12	6,200	113	103	0.08	6	4

Penstock velocities are, with the exception of the Mongaup plant (a base load plant), from 0.06 to 0.08 $\sqrt{2gh}$ — usual values. Losses are small except for the long Toronto line.

Power House. — Table V gives dimensional data of the Swinging Bridge and Rio power houses, and for comparison, similar data for some other plants. For the head developed the unit areas and volumes per horsepower for the Mongaup plants are low, indicating, as already noted from the plans, the compact design of these power houses.

TABLE V. — POWER HOUSES — MONGAUP PLANTS

PLANT	Total Horse-power	Units	Head (Feet)	POWER HOUSE		Square Feet per Horse-power	Cubic Feet per Horse-power
				Area (Square Feet)	Volume (Cubic Feet)		
<i>Mongaup River</i>							
Swinging Bridge	7,000	1	125	1,380	45,000	0.20	6.4
Rio	14,000	2	185	2,100	67,000	0.15	4.8
<i>Other Plants</i>							
Davis Bridge	60,000	3	360	6,800	30,600	0.11	5.1
Searsburg	6,000	1	230	1,100	28,000	0.18	4.7
Utilities Power Co.	7,500	3	53	4,200	120,000	0.56	16.0
Crescent	4,000	2	26	6,860	310,000	0.86	38.8
Mollys Falls	7,000	1	350	940	32,000	0.13	4.6

Wheel Velocities, Rio Plant. — Velocities for the Rio wheels and usual practice are as follows (expressed as a ratio $\frac{V}{2gh}$):

POINT	Rio Plant	Usual Practice
Scroll entrance	0.12	0.10 to 0.20
Runner discharge	0.23	0.18
End of draft tube	0.06	0.05

The specific speed of these wheel units is about 49, as compared to 46 by Whites formula, $N_s = \frac{632}{h}$.

Velocities and specific speed therefore accord with usual practice.

Penstock Cradles. — The elastic penstock cradles are of much interest and are a novel feature in penstock design. Consideration of their

design would indicate that they are economical as well as an improvement on the usual rigid form of cradle.

ARTHUR C. EATON: * This Mongaup River development Mr. Uhl has so interestingly described to us is similar in some respects to the Deerfield River development of the New England Power System, and suggests several interesting comparisons. I appreciate it is rather dangerous to try to make comparisons without close study of the detailed data, but on looking up some old precipitation records I noted that the drainage area of the Mongaup River has a rainfall relatively high, similar to the Deerfield River drainage area.

I was quite interested in Professor Barrows' figures which showed a run-off of about 2.2 second feet per square mile. The Deerfield River run-off at Shelburne Falls is about 2.1 second feet per square mile on the average. Comparing the three lower Mongaup plants with the three lower Deerfield River plants gives results as follows:

Storage in million cubic feet per square mile:	
At the three Mongaup plants	18
At the three Deerfield plants	16
Capacity in kilowatts:	
At the three Mongaup plants	24,000
At the three Deerfield plants	21,000
Capacity in second feet per square mile:	
At the three Mongaup plants	4.0
At the three Deerfield plants	3.9
Annual output — kilowatt-hour:	
At the three Mongaup plants, estimated	87,000,000
At the three Deerfield plants (actual)	90,000,000
Annual output per square mile per foot head — kilowatt-hour:	
At the three Mongaup plants	997
At the three Deerfield plants	1,020
Hours of capacity use per year:	
At the three Mongaup plants	3,900
At the three Deerfield plants	4,300

This, I think, shows rather remarkable coincidence of results or similarity of streams. This comparison I wish to use as a point of departure and the basis for asking Mr. Uhl a question.

The three Deerfield River plants were put in operation sixteen years ago. If built today they would have capacities of something like twice what they now have. This would be in line with present practice in combined steam-hydro systems, whereby the small number of

* Hydraulic Engineer, New England Power Company, Boston, Mass.

hours per year peak loads are more economically carried by hydro power and the high load factor power is given to the steam plants of a combined system. Now the Mongaup system has a 15,000 Kva. steam plant which was rebuilt in 1927, and which I assume has a reasonable fuel economy. If this is true I would like to ask Mr. Uhl why this steam plant is not operated more as a base load plant and the hydraulic plants developed with larger installations for use more as peak load plants?

HOWARD M. TURNER: * I think the point Mr. Eaton has brought out was something that I also had in mind; that is, the capacities of these plants for use as peak load plants. Mr. Uhl stated that the Swinging Bridge plant was a peak load plant, and the wheel was designed for a long period of shutdown. I couldn't see that it was very much larger than the other plants as regards the size of development compared to the river flow. It would be interesting to know how these plants fit into the daily load curve, and the demand throughout different periods of the year.

In this connection, the New England Power Company's Davis Bridge development is, of course, developed very high on stream flow. I think the figure is something like 10 or 11 cubic feet per square mile. This intensive peak load use of a water power plant is being carried still further in the new Cobble Mountain plant that the Turners Falls Power and Electric Company is building to lease from the city of Springfield in connection with the new Cobble Mountain Reservoir of Springfield water supply. It will have a capacity of nearly 20 cubic feet per square mile and will be mainly used for relay purposes of filling in the low-water periods of other plants. I think we shall see a great deal more of this development of water power for high capacity use either on daily or seasonal peaks, particularly in connection with water storage. The reason for this is quite clear; in developments of this sort additional water power plant capacity over and above the underlying initial development can often be put in cheaper per kilowatt than steam plant capacity, and uses very little water to run high capacities on short hour loads.

I was interested, also, in the design of the cradle for supporting the pipe line, and think it would be interesting if Mr. Uhl would tell us how much flexibility those cradles have been required to take; that is, how much spread there has been as showing how necessary the flexibility is.

* Consulting Engineer, 12 Pearl Street, Boston, Mass.

Another matter which interested me was the provision to take care of trash at the entrance to the penstocks through the earth dams — whether racks were provided at the inlets of the penstocks and conduits, and, if so, how they are cleaned in case they get clogged in any way.

I noticed at the downstream toe of the dam for the Rio plant the bucket is carried out horizontally, whereas at the Delaware plant it was given an upward tilt. I wondered why there were two forms of downstream toe on these two very similar dams. Also, whether any other precaution beyond a somewhat long apron was made to take care of the high velocity coming off the dam to prevent erosion, particularly in cases where the rock is not at the surface on one side of the river.

I was interested in the use of Inertol as a protection at the Rio dam, and wondered whether Mr. Uhl thinks that it has added much to the water-tightness.

There are a number of further items of interest, but one could go on at great length with respect to the details of a development of this sort, and these were several of the points which especially interested me.

EDWARD A. GRAUSTEIN:* Mr. Uhl has prepared a very interesting paper on a very interesting series of developments. A good many of the points I intended discussing have been discussed, but I would like to mention a few points which Mr. Uhl has not brought out in his paper, in regard to the economy of these water powers.

The author has noted that the valley of the Mongaup River is largely free from improved roads, industries, railroads, agriculture and water power development. This comparative lack of development of any sort was a favorable factor, as the absence of these features has had a direct effect in keeping down the cost of these developments and making them economically possible.

A second important fact that was necessary to the initiation of this development is that the developments are under unit ownership, which makes possible expenditures in storage and pondage regulation which probably would not be otherwise justified, although clearly of economic value.

The third reason for the development of these plants, and the most important, is in their location with respect to market. The center of gravity of the power on the river is about at the Rio station, approxi-

* Engineer, 6 Beacon Street, Boston, Mass.

mately 9 miles from Port Jervis. Port Jervis, at the confluence of the Delaware and Neversink Rivers, is located at approximately 6 miles downstream from the power house of the Delaware development. Port Jervis had a population in 1920 of 10,000 people. Middletown is some 13 miles from the Rio power station, and had a population in 1920 of 18,400 people. Nyack, New Jersey, another city mentioned, has a population of 4,400 people and is 32 miles distant.

To summarize, if the communities centering about Nyack are assumed as large as Middletown and Port Jervis, the center of the load is not over 20 miles from the Rio station. All distances are air line and are illustrative only. I wish to bring out the fact that this development of power has five outstanding advantages, which is unusual.

First, there are comparatively small amounts to pay for damages; second, they are near a fairly large market; and third, they are in the hands of one company for development without intervening ownership. There is a fourth favorable factor, and that is the high run-off, which I understand from Professor Barrows is 220 cubic feet per second per square mile, or about 20 per cent greater than our average New England river. The fifth favorable factor is that natural basins are available for storage development.

There are streams similar to this in New England where much of the power will remain undeveloped for a long time, yet in many respects they are equal to or better than the Mongaup River developments. The reason for this is the fact that one of the five factors mentioned is not favorable.

Water power today may be classified as to market into three fairly distinct subdivisions.

The first class includes those comparatively large powers which can be transmitted to the large load centers under competition with our best modern steam plants. The powers on the Mongaup River are not considered to be large or economical enough to be classified under this heading. This we may take for granted because of the fact that they lie, up to now undeveloped, as the paper brings out, within 60 miles of the largest load center in the world. Economical transmission distance of water power of the first group greatly exceeds that distance.

The second class, in which this power falls, is that of a relatively small—ten years ago it would have been a large—public utility, speaking now of the local utilities mentioned and not of their possible affiliations. This water power competes with smaller steam plants of correspondingly greater cost and lesser efficiency, and only short transmission distances are involved. There are many cases like this, and I

believe that most of our water power, in numbers, at least, if not in kilowatt capacity, will find its market in such developments.

The third group of water powers is the industrial group. With the higher fuel consumption and initial cost of steam power because of the still smaller average size of the industrial steam plant, a great deal more money can be spent for the development of water power. Lower grade water power, that is to say, a run of stream plant without much storage backing, can be and is developed, even today. This is the essential difference between this class and the two utility classes of power. No public utility today will construct a plant which has not now, or eventually will have, practically permanent power output.

In regard to the developments themselves, the plants are designed to operate on a certain definite system load factor amounting to approximately 3,500 hours a year, or a 40 per cent load factor, which approximates the usual average load factor in this part of the country.

The storage made available is considered ample to make these powers prime or permanent in output when they are interconnected with a steam plant, as they are planned to be, which is doubtless to be used ultimately for reserve or stand-by service. Under these conditions I believe that the proper capacities have been chosen, and more capacity, but not much more, may be available for future development at Mongaup Falls and Swinging Bridge.

Toronto Development. — The Toronto power development is costly because of the long pipe line and small power, and undoubtedly never would be constructed if it were not for the value of the stored water when used under the head of Swinging Bridge.

Swinging Bridge will thus control all the storage, and in complete control of the flow is a very necessary development and should be capable of operating at a load factor lower than the plants below because of its control and, also, I believe, it is best able to carry added capacity from an economic standpoint. If there were not storage or good pondage available at the plants below, the importance of a high capacity plant at Swinging Bridge would be greatly increased.

Mongaup Falls is underdeveloped, undoubtedly because of the limiting size of the present pipe line, which has a velocity of about 10 feet per second, and added capacity might be obtained here next best to Swinging Bridge.

The Rio, Delaware and Mongaup plants are the money makers of this project because of their relatively low cost or large capacity. In order to determine the relative economies of the various plants, a storage charge should be assessed against these lower developments

and credited to the upper development. In this way better control of the general design is possible, as each plant is considered on an economic basis as a unit in itself, and the proper size can be quickly established.

It will also be noted that an additional value of this kind of development lies in the fact that the capacity proposed is made up of rather small units of development. These can be built complete and absorbed by the market, with the steam plant to back them, without loss of revenue, thus avoiding any partial construction or installation of part capacity, which is much more costly than unit plant construction.

The Mongaup Falls development is unusual in that the developed fall is concentrated in a short distance. This development is probably the least expensive of all, because of the more suitable foundation conditions and short length of pipe line.

The Toronto development is interesting. The earth dam with the end spillway is an ideal type. It is not clear that the stream control conduit, later to be used as an outlet for the penstock, has any material advantage in its location, in the glacial drift on the side of the stream opposite from that where ledge is obtainable, other than that the stream bends in such a manner as to make its length slightly increased or an angle in the intake necessary.

It is generally considered that the conduit, where it is necessary to put one through an earth dam, should at least rest on, if not tunneled through, ledge, where ledge is available. This is done to insure against settlement under the very considerable load superimposed on the foundation by a dam of this height, which might result in serious damage to the conduit. An additional and equally important reason is the possibility of leakage through the dam, concentrated along the line of the conduit, much less damaging in its probable effect if the rock were used as a foundation. It would be interesting to have a more detailed comment from the author on the reasons which led to this location of the foundation of the conduit.

The ground plan shows a detail of the conduit. It will be noted that the power pipe line, eventually to be provided as shown, will pass through the conduit, leaving enough room for inspection and maintenance.

This seems to me to be a very important safeguard in the installation of conduits through dams, whether on earth or on rock. If we provide a stream control conduit through a dam for the purpose of building a dam undamaged by freshets which may rise during construction, we should use that conduit in its entirety for the installation

of the pressure conduit for the power development if no better place is available. As the pipe line is generally considerably smaller in size it can be installed in the conduit so that both it and the conduit can always be inspected and maintained. Full head in a single walled conduit passing through an earth dam, where that conduit cannot be inspected at any and all times, is a source of danger, particularly on earth foundations, where settlement may cause the rupture of the conduit and allow water under full head to pass unobstructed into the earth fill. It is apparent that it is intended to provide against this contingency at this development, and it is a feature to which attention should be paid.

The Rio development is very similar in general plan to the Mongaup Falls development, except for the fact that the pipe line is longer than at Mongaup Falls. Ledge rock is available for even more of the distance than at Toronto, and necessarily so, as room is needed for spillway. The gravity structure seems most suitable here.

An interesting means of increasing the ogee section of the dam without otherwise adding to its width is shown by the overhanging portion near the crest of the dam. The section otherwise follows average practice in the design.

The usual bucket, or reversed curve, which is of doubtful value under some conditions, is provided at the bottom of the dam, but no means of stilling the velocity is indicated, and sufficient data are not given by the drawings to determine the possible conditions during an overflow. Ordinarily some such provision should be made. This may be and probably is obtained naturally through backwater effect, and it would be interesting to have more detailed comments on the provision made for such protection.

These dams were built on a sandstone foundation, and my experience with that material is that with a heavy overflow it is liable to wash very rapidly and deeply. It is probable, however, that this sandstone is a rather more heavily bedded material.

Other interesting features of this development are the abutments of this masonry dam. In many cases similar to this, where the masonry dam has to be flanked by earth wings, difficulty always arises in determining the economical way of joining the two types of structures. The general type indicated here — that is, carrying abutments straight in the line of the spillway itself, and far enough for the earth embankment to be capable of taking the load — seems to be more economical and safe than high abutments parallel to the stream. In addition to the probable greater cost of such a structure, a good reason for not adopt-

ing abutments of the latter and usual type is the difficulty of cutting off seepage along the abutment.

In regard to the flexible cradle for a wood stave pipe line, this seems to be an economical as well as a flexible arrangement, as a flat plate tension member readily curved to shape is used to furnish the direct pipe support, and simple angle columns carry the reactions to the foundations. The parallel reinforced concrete continuous footings seem to have some advantages over the usual type.

The power station is a very good example of a modern design, the keynote of the construction being simplicity and economy, and the result seems to have worked out in a substantial structure. There are no structural difficulties to be met with in this type of development, the stresses due to water pressure being taken by the scroll cases, probably constructed of steel plate.

The Swinging Bridge dam is almost identical in its general layout with the Toronto development. The power house, however, is at the dam, and a low-cost installation probably results after credits are allowed for storage benefits.

Here, as at Toronto, the ledge is available on one side, but not on the other, and an additional safeguard was taken here, probably because of the modified nature of the glacial till on which this dam was constructed, by placing steel sheet piling in the bottom of the core trench on the wing of the dam which has earth for foundation. Here, again, it would be interesting to have the comments of the author on the reasons for constructing the conduit on the opposite side of the river from where ledge was available, particularly when the power house could also have been constructed on ledge, and more detailed information would be interesting as to the permeability of the material which made the sheet piling cut-off necessary.

The Delaware development is comparable with the Rio development in the relative length of pipe line. Here, again, the author points out that it has been difficult to provide the necessary room for the structures on ledge, and an ingenious means of providing the intake under the spillway has been provided. Sheet piling has also been furnished underneath this dam. Comments are impossible without more detailed information as to the character of the material. The same type of spillway structure is used as at the Rio development, except in the treatment of the overfalling sheet. Here a curve at the bottom is provided which rises to the lower end of the outlet. A vertical step instead of a curved incline might prove more efficient and economical. The side walls are also converged towards the main sheet which will have some stilling effect.

In conclusion there are five factors favorably affecting these powers: first, there were few natural falls, and no large industries were established with consequent development of the valley; agricultural development was also unimportant and property of little value; second, because of the nearness to market; third, because of the unit control of the area; fourth, a high stream flow; and fifth, good storage was also available.

The capacities chosen seem well adapted to the stream flow and probable load, with chance for some increase, the storage seems to be adequate, and the construction seems to be sound and economical.

WILLIAM F. UHL: Professor Barrows asked about the cost of the flexible cradles for the wood stave pipe. A careful detailed study of the various types of cradles often used for this purpose was made and the estimated costs were compared, and it appeared that the flexible type adopted would cost less than the others. It should be pointed out that, due to the flexibility of this cradle, it is not quite as convenient for assembling the wood staves during erection as a rigid cradle, but this is of no great importance. Temporary supports can be placed under the steel band during erection to facilitate the assembly of the staves.

Mr. Turner asked about the distortion of the wood stave pipe. This was carefully measured during the first filling of the pipe, and was found to amount to about 6 inches.

Mr. Eaton showed that there was a marked similarity in extent of storage and development between the lower Deerfield River developments by the New England Power Company, some twelve years ago, and the present developments on the Mongaup, and he stated that if these Deerfield River developments were carried out today the installed capacity would be materially increased so that the plants could carry peak loads, and thus save the installation of steam capacity for the system. Mr. Eaton asked why greater capacity is not being installed in the Mongaup River plants.

The answer to this question is somewhat involved. In the first place, it makes a difference as to what type of development we deal with. Additional capacity can be installed at much less cost in a so-called concentrated development where the power plant is at the dam than where it is necessary to use a long conduit to carry the water from the dam to the power plant. The cost of the conduit becomes an important item in such a development, and therefore the increased cost for additional capacity is relatively great.

The demand for capacity must also be considered. Where a plant feeds a large system with demand much in excess of the water power

available, the additional peak load capacity of the hydro-plants is valuable. In the case of the Mongaup River developments, these are being carried out to provide capacity and output for a load limited to the company's own system, and it would not pay to carry the capacity of the plants much beyond their ability to produce kilowatt-hour current as well as kilowatt capacity as required by the system. The amount of money that should be expended on capacity for future use is difficult to determine. In this case it was found that steam power for carrying a base load could not be produced at as low a cost as water power developed about as needed.

Mr. Turner asked if racks were provided at the intakes to the conduits under the earth-fill dams. Racks are provided. They are comparatively coarse racks with a very low velocity through them. It is doubtful if much material will ever lodge against them. No provision is made for cleaning them except by drawing the reservoirs down until they become accessible. Loss of head would indicate that the racks might be obstructed, and in emergency they could be cleared by a diver. Experience indicates that such obstruction is a rare occurrence.

The matter of erosion of the rock below the concrete spillways has been mentioned.

Both the Rio and Delaware dams are designed with comparatively wide aprons, and it will be noted that the crest of the dam is much longer than the aprons. This causes the water coming from the sides to impinge upon the water coming down over the center of the crest, and in this way much of the energy of the overflowing water is destroyed before leaving the apron. A great deal of water has already passed over the Rio dam.

The year 1928 was an extremely wet one as far as the Mongaup drainage area is concerned. Two floods, one in June and one in August, caused peak flows of about 45 cubic feet per second per square mile at Rio, and a depth of about 3.8 feet over the crest. No serious erosion is so far in evidence. After the river is fully developed it is not expected that much water will be wasted over any of the dams.

The value of the Inertol treatment on the upstream face of the Rio dam has been questioned. The dam is very tight. To what extent this is due to the Inertol treatment it is not possible to say. It is believed it has some merit. It is also being used on the outlet tower of the Swinging Bridge development, and we have used it on a number of other jobs. The Swinging Bridge tower is remarkably dry. We believe that the water-tightness of the Rio dam is partly due to the Inertol treatment and partly due to the care with which the concrete was placed, its consistency, and the care taken in cleaning the construction joints. The latter,

I believe, is the most important thing to carry out in the building of a good, tight, concrete dam.

Mr. Graustein has pointed out that the single ownership of the water rights on the Mongaup River was important. That is true. Such a river could not be economically developed without storage and ample pondage, and unless the control is in the hands of one company this could not be handled efficiently.

The diversion and outlet conduits for the Toronto and Swinging Bridge developments were carefully considered, and estimates of cost for tunnels through the rock banks and conduits founded on rock were made.

The difference in estimated cost was a material item, and it was decided that the extra hazard in founding the conduits on glacial drift was not sufficient to warrant the extra cost of building them in or on rock.

The time element also affected the decision.

It is very desirable, if feasible, to build on a rock foundation, but sometimes it is not economical to do so. It then becomes a matter of experience and judgment as to the hazard taken by building on a slightly yielding foundation.

The sheet piling driven under the cut-off trench for the Swinging Bridge dam was not originally included in the design of the dam. It was added as an additional safeguard against underseepage when the cut-off trench was being constructed, as the material under the river bed was not as impervious as at the Toronto dam site. We believe the dam would have been satisfactory without the sheet piling, but the cost of this item was not great, and it was thought to be good judgment to use it in this case. At the Delaware dam site the material is less impervious than at Swinging Bridge, and the sheet piling is provided for in the design.

These dams will not be absolutely watertight, but, covering such a tremendous area and distance up and down stream as they do, built of relatively impervious material, it is practically certain that only a small amount of water can find its way through or under these dams. It is almost certain that water cannot pass through these dams, because the cores as built by the hydraulic method are practically impervious. Some water may pass around the ends or under the dams, but not in any such quantity that it would endanger the safety of them or be of economical consideration. Such dams should be built very safe, and it is quite possible that dams with steeper slopes and less material in them would be absolutely safe with materials such as these dams contain.

Some boulders were encountered in driving the sheet piling, but for the most part it went down very well, and it is hoped that it will do some good.

The Inertol was applied to the face of the Rio dam with a brush. Two coats were applied. The application at the Swinging Bridge tower was by spray. The latter is the better method to use. Inertol is a patented inert coal tar preparation.

We used Douglas fir for the Rio wood stave pipe in preference to cypress, because at the present time the Douglas fir is cheaper and of more uniform quality. This is the first large wood stave pipe that we know of where creosoted Douglas fir was used. It is expected that this treatment will increase the life of the pipe by about ten years. The top half of the pipe was also treated with asphalt. This was sprayed on hot after erection. The extra cost of the creosoted staves over plain staves was about \$30,000 for the 7,000 feet of pipe, and the extra cost of the asphalt spray treatment was \$10,000. The latter treatment fills the joints and defective places in the staves, and will prevent the accumulation of dirt and consequent growth of fungus.

The creosoting specifications called for an 8-pound vacuum pressure treatment.

The continuous parallel type of footings for the wood stave pipe were used on soil foundation for several reasons. These are, first, because it was estimated that it would be cheaper to build them than the cross footings commonly used; and second, because they made it possible to haul material between them for distribution along the line. They are 12 feet 4 inches apart. Cross footings would have required the same amount of concrete to obtain the unit bearing area desired. The footings were not carried below the frost line. The pipe was built and filled in the same season that the footings were poured in, and it was considered unnecessary to carry them below frost line for this reason. Where the footings are on a rock foundation, individual rectangular structures are used.

The boulders encountered in the borrow pits by the sluicing operations amounted to about 5 per cent of the total material. As the sluicing proceeds, everything disappears except the boulders, which are too large to pass through the sluice pipe or be transported by the water, with the result that the borrow pits become paved with boulders after some time. During the construction of the Toronto dam, not much attention was paid to the boulders except that occasionally a power shovel was used to clear them from points where additional sluicing was planned for. At Swinging Bridge the accumulated boulders were

loaded on trucks by power shovels and hauled to the slopes of the dam, thus continuously keeping the borrow pits clear. This was one of the reasons why less power was required at Swinging Bridge than at Toronto. Some of the other reasons for this were the steeper slopes at which it was possible to carry the sluice pipes and the shorter distance between the borrow pits and the dam.

Two sluice pipes were used to transport the borrow pit material to the dam on each slope, as this made continuous sluicing possible. In order to get uniform wear, the pipes were frequently turned through a small angle. This could not be done while they were in use. They were also out of use when mounting them on new trestles or relocating them in the borrow pits.

IRVING B. CROSBY (by letter):* Mr. Uhl mentioned the geological conditions and the fact that the pre-glacial bed of the river is buried at varying depths below the present river. Further discussion of the geological features of these developments may be of interest.

The explorations for these dams have proved the existence of a pre-glacial gorge buried deep below the present river. The pre-glacial channel may be under or just to one side of the present stream, or it may be entirely off at the side. All three of these possibilities are illustrated on the Mongaup River. At the Swinging Bridge dam the buried gorge is under the river, though a little to one side, and its floor is more than 50 feet below the river, but the exact depth is not known here or at the other sites.

At Mongaup Falls there is ledge in the river and on both banks, but field observations make it appear that the pre-glacial gorge is probably buried under glacial drift a short distance west of the present river. Apparently the filling of the old gorge is impermeable, as there is no visible leakage coming from it. When the river took its new course over the glacial deposits after the retreat of the ice, it here happened to be a little to the west of its previous channel, and it cut down on a rocky spur and became intrenched in the rock. Below this spur it eroded easily to a lower level, and the water falling over the ledge cut back, forming the short gorge below Mongaup Falls. This gorge marks the amount of erosion in sandstone of which this stream has been capable since the disappearance of the ice. The situation here is similar to that at the lower dam at Fifteen Mile Falls, New Hampshire, where the buried gorge is concealed at one side.

At the Rio dam conditions are but slightly different. There is ledge

* Consulting Geologist, Boston, Mass.

on the east side and in the river, but on the west side it rises only a short distance above the river and then drops off, presumably into the pre-glacial gorge. This is comparable to conditions at the upper dam at Fifteen Mile Falls, where there is ledge in one bank and under the river, but not under the other bank.

It is probable that this buried gorge is continuous from the upper part of the river to its mouth. The depth to the floor of this old gorge undoubtedly varies, but it is probably greatest about midway between the headwaters and the mouth of the river.

Buried pre-glacial valleys which are often true gorges are known in many places throughout the glaciated regions, and this condition is believed to be very common. Other dam sites with similar conditions have been studied on the Connecticut River in New Hampshire and Vermont, on the Kennebec in Maine, on the Moose, Beaver and Sacandaga rivers in the Adirondacks, and on the Saint Maurice River in Quebec.

In selecting a dam site in the glaciated regions it is safe to expect a buried valley, and if rock shows on both sides of the river and in its bed it should be ascertained whether there is a pre-glacial valley filled with permeable material which can act as a by-pass around the dam.

The geological conditions on the Mongaup River are typical of the glaciated regions, and illustrate what may be expected in New York, New England and Quebec. The character of the rock and of the glacial deposits will vary from place to place, but similar relations of the present and buried valleys are probably the rule.

THE NORTHERN LUZON TRIANGULATION

ELLIOTT B. ROBERTS *

THE writer went to the Philippine Islands early in 1926 to undertake a control survey project of particular interest because of the unique conditions to be met. Charting work in project by the United States Coast and Geodetic Survey made necessary an arc of triangulation in northern Luzon, extending from existing control in the Central Valley, near Lingayen Gulf, to the base net at Aparri, at the mouth of the Cagayan Valley. This distance, nearly two hundred miles, is, perhaps, one-third rugged mountains and two-thirds rolling hills, interspersed with areas of low swamp land. Our lack of previous experience in this area was responsible for the utmost uncertainty as to probable best methods and time required.

The country is extremely wild; in fact, incompletely explored. There were known to be many tribes of uncivilized mountain people of varying degrees of savagery, certain animal dangers, such as pythons and wild carabao, or water buffalo, and the usual insect pests of the tropical jungles. It was, therefore, with great interest, heightened by some apprehension for the unknown, that the working field was approached.

The geographic position of Aparri had already been established, approximately, upon the Luzon Datum, the primary geodetic control of the Philippine Islands, through early triangulation, executed at a time when the tribes retained much of their original savagery. In those days there was great danger in penetrating inland from the coast. Accordingly the control, reaching Aparri via the west and north coasts of Luzon, was composed largely of narrow and weak figures of triangulation.

This condition was far from satisfactory, owing to the growing commercial importance of the Aparri region, and to the extensive area of the northern island groups, the charting of which must be based on the Aparri data.

Proposed charting of the northeast coast of Luzon would supposedly involve the extension of control surveys from Aparri eastward and southward toward Casiguran Sound, which was the terminus of

* Junior Hydrographic and Geodetic Engineer, United States Coast and Geodetic Survey, Washington, D. C.



FIG. 1. — MAP OF NORTHERN LUZON

Dot and dash lines show triangulation system described in this article. Base lines are shown in Lingayen and Aparri

existing surveys of the east coast. Examination of this region disclosed the existence of a coast so precipitous and rugged as to make virtually impossible the usual form of coast triangulation. Immense cliffs formed the shoreline, and the towering peaks of the Sierra Madre lay immediately behind. Some fifty miles inland, however, lay the broad reaches of the Cagayan Valley. It was a logical step to consider reaching this coast with control coming directly over the mountains from the passable regions beyond. This idea, when carefully investigated, resulted in the plan for a primary arc of strong triangulation, based on reliable Luzon Datum points in the Central Valley. Crossing the Cordillera Central, the mountain backbone of Luzon, and traversing the length of the Cagayan Valley, a framework would thus be available on which to base all northern Luzon surveys. The points thus determined would furnish starting data for extensions over the Sierra Madre to the east coast, and Aparri would become firmly established on the Luzon Datum.

The planning of this work involved study of how best to utilize the engineering and economic possibilities. This resulted in an agreement with the Bureau of Lands of the Philippine Islands whereby control points would be established according to the needs of the cadastral surveys of arable lands in the Cagayan Valley. To further the work, and to establish the nucleus of a geodetic survey corps of their own, that bureau agreed to furnish a number of their own surveyors, as assistants and apprentices. So great was their interest that a large share of the expense was undertaken by that bureau.

SCOPE OF SURVEY

The following became the prime objectives: (1) completion of a primary connection between the Central Valley and the Aparri base line; (2) planning of extensions to the east coast, and, as far as possible, performance of such work; (3) establishment of cadastral survey control points; (4) training of the Filipino assistants in geodetic survey work. The planning and the carrying out of the survey to accomplish these results constituted the work of the writer for nearly two years.

The Cagayan Valley consists of perhaps four thousand square miles of broken country, composed partly of river flats and flood plains, and partly of rolling grassy hills. The topography is abrupt, the plains and hills being broken in all directions by deep ravines, filled with almost impenetrable jungle, prohibiting easy travel in any direction. Trails

are numerous near the settlements, but are generally impassable for vehicles of any sort. In small localities bull carts and sledges are used, but travel is mostly by horseback, water buffalo and walking. These mediums were all used in the course of the work, but the most extensive use was made of human packers.

East of the valley lies the Sierra Madre, its peaks reaching over six thousand feet in height. In area approximately equal to the valley, this region was practically unexplored, knowledge being limited to the land adjacent to the one trail across. Here there is a remarkable topography. The mountains are the upper edges of sharply tilted strata; the valleys are formed by fault line displacements; and the



FIG. 2. — SCENERY IN MOUNTAIN PROVINCE

escarpments are cliffs thousands of feet in height. A dense stand of virgin timber blankets all but the sheer cliffs. Tremendous river falls are on every hand. Volcanic activity exists, but in general the country consists of stratified rocks, sandstone and limestone, interspersed with igneous intrusions. Valuable mineral content is promised on every hand. Truly a remarkable prospect for future development!

Travel in the Cagayan Valley has been greatly simplified since the opening, about six years ago, of the Cagayan Valley Road, a main artery affording nearly constant automobile travel during the dry season, and intermittently at other times. The general scene of operations was, therefore, reached by truck, and travel by more laborious means was limited to short expeditions from the nearest highway points.

RECONNAISSANCE BY AUTOMOBILE, BOAT AND AIRPLANE

In April, 1926, the writer, accompanied by two assistants, began field work, — a reconnaissance trip by automobile and river launch covering large parts of the desired area. The topography was studied and many hills ascended. In certain places this cursory examination was adequate for the formation of definite plans, and in others a fairly good tentative layout resulted. In hilly country affording open vantage points such work is fairly easy. Many stations can be selected without visit, the intervisibility between hilltops being easily established from



FIG. 3. — OBSERVING PARTY

a distance except in rare cases. Working from such rough maps as were available, by the use of sextant and altazimuth, the positions and elevations of hills were found with sufficient accuracy for reconnaissance purposes. There were regions, however, of such ruggedness and difficult access as to appear formidable in the extreme. Particularly difficult were the trailless and densely forested mountains of Nueva Vizcaya Province. The forests are difficult of access, being luxuriant tropical growth in which trail cutting is a fine art.

Through the co-operation of the Army Air Corps, a long airplane flight was made over the east coast and the Sierra Madre. Thus was made available more complete knowledge of this remote area than had ever been known. The principal value of the flight lay in the discovery

that the highest peaks were visible alike from the Pacific Ocean and from the Cagayan Valley. This was of great importance in view of our plans, although a close view of the country was hardly encouraging to the engineer who expected to penetrate to its peaks with theodolite and heliotrope. It was on this three-hour flight over such an area that the observer was afforded the real thrill of hearing the sudden cessation of all activity on the part of the motor. Visions of a parachute landing in two hundred foot trees, and of a fifty-mile hike to the nearest food and shelter, through uncut jungle, ensued during the tense moments



FIG. 4. — CARABAO SLEDGES TRANSPORTING EQUIPMENT

until the pilot, with very commendable skill, located a stoppage in the fuel supply, and put an emergency pump in operation.

By the end of the dry season a satisfactory scheme had been devised for the northern two-thirds of the work. While the high mountains remained to be crossed, it appeared likely that a scheme of sufficient strength was in prospect to obviate the necessity of a base line intermediate between the termini. This was eventually proven to be so.

FIELD OBSERVATIONS

After the worst of the rains were over, late in 1926, a working party was organized to take up field observations. Six Filipino surveyors were outfitted with camping and signalling equipment, each taking charge of

a field unit. After thorough instruction in their duties, they were dispatched to their stations, the chief of party heading the observing unit.

Observations of horizontal and vertical angles were made with Fennel direction theodolites of eight-inch diameter circles. A direction was considered determined when measured in the direct and reversed telescope positions on each of eight circle positions, provided no value differed more than four seconds from the common mean. Vertical angles, by the double zenith distance method, furnished data for a trigonometric level computation giving elevations of all stations within a probable one or two meters. Instruction in observing constituted daily routine for the Filipinos during occupation of their respective stations. They learned quickly, and by the end of the current season two regular observing parties were in operation, each in charge of an assistant. This permitted simultaneous observation at more than one station, — an absolute necessity because of the scarcity of clear weather.

The work of the assistants was excellent. In prompt learning, and in rapid but careful handling of the instruments, they could hardly be excelled. Their ability to assimilate instruction, and meticulously to carry out definite orders, made them highly satisfactory as assistants. They were seriously deficient in originality and judgment, but close supervision, constantly maintained, overcame this handicap.

The Cagayan Valley is subject to the poorest observing conditions imaginable. Several months of the year are subject to frequent typhoons, the lowlands being flooded, and the entire country being devastated by cloudburst and gale. Of the remaining months many weeks are lost in strong monsoons and constant rain. Perhaps 15 per cent of the time is calm and sunny, but at all such times, between the heavy natural haze and the smoke from countless grass fires, visibility is very low. Strong electric searchlights were seldom visible twenty miles at night. Banners of whatever size became indistinguishable beyond twelve to fifteen miles. Even the heliotrope could be seen only on the best days at thirty to forty miles.

In this, the Cagayan Valley section, the stations varied between a few hundred and three thousand feet in elevation. Those most distant from the highway required two to three days of hard foot travel to reach. While the area is partly forested, it was usually possible to find bare peaks as stations. The hills selected were the foothills of the high mountain ranges bordering the valley. The adopted scheme was a compromise between accessibility and ease of occupation on the one hand, and strength (particularly, width of scheme) on the other. In a few places it was necessary to erect observing towers, saplings being used. Bamboo struc-

tures were used to elevate signalling apparatus, but were found too light for instrumental supports. Much cutting of timber was done to reduce the amount of tower construction.

Living conditions were bad (or worse). The material comforts of the civilized world had to be left behind. Regular cooks were unobtainable on such expeditions, and the half-hearted efforts of untrained Ilocano boys had to be endured. Weeks were spent on the trail in constant rain, bedevilled by myriads of enormous leeches and ferocious mosquitoes, plowing, hip deep, in swamp mud, or climbing thousands of feet on sixty-



FIG. 5

Left — LARGE BANNER FOR LONG LINES ON HIGH MOUNTAIN STATIONS

Right — TYPE OF CONSTRUCTION OF OBSERVING TOWERS

degree slopes. The camps were often in small clearings in dense jungle, constituting very trying confinement over the long periods, often many weeks, when operations were halted by storms. When canned goods became unbearable, rice and the inordinately tough native chickens were the only alternatives. Water, except upon very remote peaks, or when rainfall was caught direct, had to be boiled, on account of the danger of pollution by the mountain-dwelling tribesmen. Boiling undoubtedly killed germs, but it didn't remove the slime. The opportunity to sleep in the thatched houses, and eat the meals of the poorest Filipino farmers, was, by comparison, a treat.

Trucks, bull carts or sledges carried the equipment as far as possible in the general direction of a station, there to be delivered to the packers assigned to us by the head man of the last outlying settlement. These men received ninety centavos (forty-five cents) a day. They worked very cheerfully for this amount, and evidently appreciated an excuse to make a trip into the hills, where they gathered rattan and other desired forest products. From fifteen to thirty would be so employed, great hilarity and shouting giving a holiday atmosphere to the scene. There were usually a few who were so proud of the great loads they could carry as to jeer at the less enthusiastic, thus spurring on everybody. A meal for one of them consisted of the rice contained, when boiled, in a



FIG. 6. — CAMP PARTY AND GUARD

joint of bamboo (18" x 4"), and a mouthful of dried or fermented fish. A man could carry several days' rations in a small bundle hanging from his waist. For the night's shelter, a few strokes of the bolo provided sticks and palm leaves sufficient for a rude shack. Clothing for such a trip consisted of a cotton undershirt, drawers and a wide hat of woven grass or palm. These men, the farmer inhabitants of the valley, were mostly of the Ilocano and Cagayan races, and were all Christianized.

Members of the so-called "wild tribes" were encountered everywhere. They are of varying types, differing greatly in various localities. Their common attributes are their paganism, the wearing of gee-strings, and their head-hunting rites. While most of these tribes are Malay, being distantly related to the so-called "Christian Filipino races," at

least one, the negritos of the Sierra Madre, are wholly distinct. There is no doubt that the latter rank among the most primitive people on earth. They, and one or two other similar tribes, use the bow and arrow, being highly expert in their use. With this exception, the spear and the head-axe are the common weapons. These wild people are very picturesque, manufacturing and coloring their own clothing and crude jewelry. On one occasion a camp party in a remote part of Ifugao Province was molested, probably more through curiosity than animosity. Soldiers of the native constabulary were carried as guards to the most isolated stations. These mountain people were generally apathetic toward us, and frequently appeared to avoid us as much as possible. In some cases they were used as packers. A team would generally consist of as many women as men. The women were stronger and better adapted for this work, having performed most of the heavy work since childhood, while the men busied themselves with matters of warfare.

On the approach of the rains, in June, 1927, work was again closed, having been completed to the end of the reconnoitered area; that is, to the Isabela-Nueva Vizcaya boundary. The completed part consisted of quadrilaterals and central-point polygons, averaging twenty miles in width. In addition to the observations in the main scheme, a large number of subsidiary points had been located in the agricultural areas of the valley, these constituting cadastral survey control. A long series of Sierra Madre peaks had also been connected by intersecting observations from the main scheme stations. Despite the fact that such pointings were made upon the apparent summits of wooded peaks, without signals of any kind, the checks indicated probable errors in such mountain point locations of the order of four meters. One such noteworthy determination involved a very distant peak southeast of the valley, near the shores of Casiguran Sound, the same peak being independently located by a hydrographic party working far to the southeast, near Polillo Island. Both determinations were based on the Luzon Datum, but between lay a long network of triangulation practically encircling Luzon, nearly a thousand miles in length. The agreement was within some three meters!

These located peaks, being visible from the Pacific, constitute visual control for sextant position finding in the hydrographic survey of the offshore areas in the Pacific east of Luzon, thus solving a part of the problem at hand. As for the placing of local control directly down on the east coast, the writer had time to do no more than to make a partial reconnaissance. Undoubtedly the extensions will be made, as planned, directly across the Sierra Madre from the Cagayan Valley stations.

COMPLETION OF WORK

The following dry season, November, 1927, to March, 1928, saw the completion of the work across the high mountains to a closure with the base stations at Lingayen Gulf. Here the conditions were entirely different, both as to topography and climate. The atmosphere was clearer, but cloud masses capped the high peaks almost continuously. The mountains, varying between seven and ten thousand feet in elevation, were reached through dense jungles over trails of our own cutting. By an almost phenomenal series of lucky chances, the proper peaks were selected to cross the entire area in but three quadrilaterals. These were of great size, having lines as great as sixty-five miles in length. By this time there were in operation four completely outfitted observing parties, having a quota of only two stations each. Conditions were so bad that four months were required to complete the work, an average of two months to a station. The writer could fill a book with complaining tirades on his troubles on that score. It was a happy week, in March, when the clouds held back, permitting completion of the last required observations.

As if in recompense for all the troubles hitherto met, fortune smiled when the last day of reckoning came, — that eagerly awaited but feared day, when the engineer casts up his accounts and examines into his closures. The average closure error of all triangles from beginning to end was exactly two seconds. The length check between bases, the final criterion, showed a discrepancy of approximately one part in a million! Thus was erected the survey backbone of Luzon.

THE ENGINE AS THE BAROMETER OF AIR TRANSPORT DEVELOPMENT

By B. G. LEIGHTON*

Presented before the Affiliated Technical Societies of Boston, February 6, 1929.

THE airplane is unique among transport vehicles in that there are no static forces to support it. Every one knows, of course, that its support comes solely and entirely from its propelling power plant. Every one knows, also, that a large, heavy plane requires a more powerful engine to sustain it in flight than does a small, light plane. Obviously, then, there must be some fairly definite relation between the total weight of an airplane and the power which is necessary to drive it fast enough to lift it clear of the ground; and just as obviously there must be some practical upper limit to the total weight which any given power plant can lift. Certainly we cannot hope to carry an indefinite weight with zero power. Stones do not float in air. Since the lift is derived from the power of the engine, there must be some limit to the gross weight which one horsepower can sustain in flight.

The story of the development of airplanes is written very largely in three words, — "pounds per horsepower." Power loading, that is, "pounds per horsepower," is the predominating factor in all aircraft design. One does not have to be an aeronautic engineer to know that if we want high speed, quick get-away, rapid climb, we must keep our weights down and the power relatively high. Any one who has ever pushed a wheelbarrow found that out on his first try. If we wish to carry heavier loads without increasing power, we must accept slower speeds, longer runs at the take-off and inferior maneuverability. And obviously, it is possible to load any airplane down to the point where its engine will not lift it from the ground at all; at that point we have reached the upper limit of power loading. And for all practical purposes, that limit today stands at about 25 pounds per horsepower.

In other words, if we try to build a practical airplane whose weight exceeds 25 pounds for each horsepower developed by the engine, the probability is that it will not lift itself from the ground. In that total

* Director of Sales and Service, Wright Aeronautical Corporation.

weight must be included the plane structure, engine, propeller, fuel, pilot, freight — everything.

Greater weights have been carried and can be carried again in special stunt machines, of course, but so far as any practical utility is concerned, 25 pounds per horsepower stands today as the practical upper limit of gross weight that can be carried. One horsepower, 25 pounds, 100 horsepower, 2,500 pounds, and so on. That limitation applies to all sizes and types of airplanes, big ones and little ones, monoplanes, biplanes and all.

In average commercial service today the gross power loading is materially less than 25 pounds per horsepower. Few passenger planes in service today weigh more than 15 or 18 pounds per horsepower; many weigh less than that. If we want high performance and maneuverability, we must go much lower than that in power loading. Military observation planes weigh less than 10 pounds per horsepower; modern high performance pursuit planes weigh 7 pounds per horsepower, or less. World record racers weigh less than 5 pounds per horsepower. Let me emphasize again that when I speak of gross power loading I include the fully loaded weight of the complete plane ready to fly, including engine, fuel, freight and crew, and when I speak of upper limit I refer to practical limitations of really serviceable planes.

With these figures prominently in mind, we may begin to appreciate the tremendously important part that the development of light power plants has played and is playing in air transport development.

The first internal combustion engine, built less than a century ago, was a very crude affair which developed less than a horsepower and weighed something over 500 pounds. Progressive development brought the internal combustion engine to the stage where it began to be used in driving horseless carriages, and then, in the last fifteen years of the nineteenth century, development was greatly accelerated by the growing automobile industry, until, in about 1900, engines were being built whose weight was in the neighborhood of 25 pounds per horsepower.

If we were to start now, with all our present-day knowledge of aerodynamics, and attempt to build a practicable airplane with such an engine, we should be foredoomed to failure, because with an engine weighing 25 pounds per horsepower the full limiting weight allowance for the complete airplane would be used up by the engine alone, and there would be nothing left for wings, for fuel, for pilot. No wings, no flight, of course.

Before we can add wings we must find some way to take some weight out of the engine. That was the problem which confronted all

the pioneers in mechanical flight, — to find an engine whose weight per horsepower came within the limiting requirements.

It is of interest here to quote from the story of Langley's early experiments, written by the man who did his engine development work. Mr. Charles M. Manley. Mr. Manley, in the "Langley Memoir on Mechanical Flight," published in 1911, says of the period in 1898:

Although the problem of construction, the frame, wings and all other parts . . . seemed indeed formidable, it was believed that the greatest obstacle in the production of such a machine would be that of securing a sufficiently light and powerful engine to propel it.

Preliminary experiments with models had convinced them that an engine of not less than 12 horsepower with a weight of not more than 100 pounds was necessary.

It seems well-nigh incredible to us, who today take as a matter of course the engines of several hundred horsepower whose weight is less than a pound and a half per horsepower, that only thirty years ago an intensive search of two years should fail to find any man in the world who could build an engine which would develop 12 horsepower with a weight of 100 pounds, yet here is the testimony of the man who made the search:*

After making a most extensive but fruitless search . . . in this country, it was decided that it would be best to see what could be done in Europe. . . . Some six weeks were spent in visiting all the important builders of gasoline engines in Europe. . . . Everywhere the builders said that they did not care to undertake the work, and that they did not consider it possible to construct an engine of 12 horsepower weighing less than 100 to 150 kilograms (220 to 330 pounds), or that, if they had thought it possible, they would already have built it, as they had had numerous inquiries for such engines, and also wanted them for their own use.

Such was the state of the art of internal combustion engine construction in 1900. No engine in the world existed which weighed less than 25 pounds per horsepower, and most engine builders believed that such an engine would be impossible to build. Those of you who may wonder why the airplane was so long in coming into the world of practical fact, I ask to remember that with all of our present-day knowledge, and more than a quarter century of actual flight experience, we have no airplanes in regular service today, either military or commercial, whose gross weight per horsepower (including engine, fuel, plane structure, pilot, and freight) is as great as the bare weight per horsepower of the lightest engine which the world could produce thirty

* Langley Memoir on Mechanical Flight, page 219.

years ago. It is possible that we might today, with such heavy engines, build a man-carrying airplane that would fly, but even that is doubtful. Certainly such an airplane would have no practical value for either military or civil use.

I have no slightest thought of disparagement of the splendid work of the Wright Brothers when I say that had they conducted their gliding experiments five years earlier than they did, they would have been totally unable to accomplish actual mechanical flight, because at that time the art of engine building in the whole world had not yet progressed to the point where it was possible to produce a light enough power plant to lift their machine from the ground. They were living in a time of tremendously rapid development in engine building under the powerful impetus of the rapidly developing automobile industry. In the period immediately following the turn of the century, great forward strides in engine development were the order of the day, and by 1903 the art had progressed to the point where the Wright Brothers were able to build an engine of their own design which weighed about 13 pounds per horsepower. With it they were able to build a machine which would just barely fly. The machine was so lightly constructed that its factors of safety were reduced nearly to the vanishing point; its maximum speed was less than thirty miles per hour; it had to be put in flight with special launching devices; it flew but a few seconds at a time.

Mechanical flight as a visible accomplished fact began on that day, but back of that was more than a century of patient research and study in engine building by hundreds of experimenters throughout the civilized world. We think of aviation as something detached, a new discovery of the last quarter century which has suddenly sprung into being as a complete entity. In a limited sense that is true, but only in a very limited sense. I wish there were some way to bring to the consciousness of the world at large that the airplane is part and parcel of the great history of mechanical devices of all kinds whose roots go back for centuries into the beginning of the development of mechanical devices leading up to the appearance of the practical heat engine, which finally turned the early kite into the modern airplane.

The Wright Brothers were the immediate fathers of practical mechanical flight, of course, but I like to think that Carnot, who gave us the first clear conception of the heat engine, came as near to being the grandfather of mechanical flight as any one, and that Watt and Otto were as great contributors to the final success of the airplane as any other men. The airplane as we know it today is part and parcel of the

great system of rapid transport and communication which had its real beginnings in the days when those men pointed the way to practical methods for releasing the energy of the world's great fuel stores and turning it to useful account. As the art of engine building has progressed, traffic has speeded up. I think you will agree with me, if you reflect for a moment, that in practically all forms of transport vehicles the development of the engine has been the predominating, the controlling, and the limiting factor in determining the speed and carrying capacity, and hence the ultimate utility, of the vehicle. We may except only water-borne craft, but even these have been very markedly influenced by engine development.

As lighter, more powerful, and more efficient engines have appeared, faster and larger vehicles have developed, either to replace or to augment the utility of the older vehicles.

The desire to fly is probably one of the oldest dreams of mankind. The elementary principles were fairly well understood generations ago. The seemingly insurmountable difficulty had always been to find engines light enough to lift themselves and their supporting structures from the ground. The heaviest engine, so far as I know, that has ever been used in an airplane that flew weighed some 13 pounds per horsepower, and that was the engine used by the Wright Brothers, — an engine, be it remembered to their everlasting credit, which they built themselves because no other was available to them elsewhere.

Mechanical flight as an accomplished fact could not come before, — it was bound inevitably to come when light power plants appeared. And as lighter, more efficient power plants have been produced, airplane performance and utility have progressed.

Starting, then, with an engine of 13 pounds per horsepower, and with an airplane which will just barely fly, with no useful load, trace the influence of weight reduction on the development of the airplane. If we take a pound from the weight of the engine, that pound is a pound which may be added to the useful load, to the fuel supply, for a larger freight, to permit carrying a greater load of freight, or to the structure to make it stronger and safer. Or, if we prefer to leave it out of the machine, it is a pound less that the engine must support, and the saving may be translated into superior performance of the machine, — quicker take-off, higher speed, increased maneuverability.

Let us take a specific example — a machine such as Lindbergh used in his flight to Paris. His total weight at take-off was about 5,300 pounds, made up about as follows: airplane structure and fittings, about 1,900 pounds; bare power plant, about 550 pounds; fuel

and oil, about 2,600 pounds; pilot and miscellaneous gear, about 300 pounds. His engine developed about 220 horsepower. His gross power loading was approximately 24 pounds per horsepower, and he was loaded dangerously close to the limit of ability to take off. Note that the total power plant weight, including engine, fuel and oil, was about 3,150 pounds, or 14.3 pounds per horsepower. His engine weighed about 2.5 pounds per horsepower, and his fuel and oil about 11.8 pounds per horsepower. Note the distribution of the total power plant weight as between bare engine — and fuel. Of a total of 14.3 pounds, 2.5 pounds were allotted to the engine, and 11.9 pounds to fuel and oil. Now suppose that he had been forced to use an engine of weights such as obtained in 1903. No increase in the total power plant weight would have been permissible, because as it was the machine was loaded to the very limit of its ability to take off. Necessarily an increase in bare engine weight would have required a corresponding decrease in fuel weight, and with a 13-pound engine such as the Wright Brothers were compelled to get along with in 1903, it would have been necessary for Lindbergh to reduce his fuel weight from 11.9 to 1.3 pounds per horsepower. With the modern light engine at 2.5 pounds per horsepower, Lindbergh had 550 pounds of engine and 2,600 pounds of fuel and oil. If he had been forced to use an engine weighing 13 pounds per horsepower, he would have had 2,860 pounds of engine and 290 pounds of fuel and oil. The length of possible flight with any given airplane is, of course, proportional to the amount of fuel which can be carried. With his 2,600 pounds of fuel and oil, Lindbergh flew approximately 3,900 miles to Paris. With 290 pounds of fuel and oil he could fly roughly, 450 miles.

In other words, if we measure the advance in the performance of aircraft in terms of possible distance flown, starting from a few feet in 1903 and advancing to 4,000 miles at present, we shall be not far from the truth in saying that approximately 80 per cent of that advance has been due to sheer reduction in engine weight per horsepower, and the remaining 20 per cent to all other factors combined.

That is a bold statement, I admit. Possibly it is greatly exaggerated, though I have been unable to convince myself that there is any great fallacy in it.

At any rate, there is enough of truth in it to offer convincing proof of my contention that the power plant has been and is the predominating influence in aircraft development. I do not belittle the tremendously important work of the aerodynamic and structural engineer. As higher powers and higher speeds have come forward, the stresses on the

structure have become greater and the structural engineer has been finding ways to provide the additional strength without corresponding increase in weight. The work of the structural engineer has kept pace with power-plant development, and is inseparable from it, but the driving and supporting force of the airplane is the engine, and the controlling and limiting factor in the development of air transport has been, is, and I believe will continue to be, the development of the power plant.

From one viewpoint, we might say that, if that is true, we are approaching the limit of possibilities in air transport, because with engine weights today averaging little more than 1.5 pounds per horsepower, we have not much farther to go; that is, one might say that if we were to find means to build the ultimately perfect engine whose weight is zero, we should not realize a great increase in possible performance. That is in a sense true. For example, reverting to Lindbergh's machine, if he had had a weightless engine, he would have been able to increase his fuel weight from 2,600 to 3,150 pounds, and his possible flying distance about 25 per cent. That is, of course, not a literal statement of fact, for we are developing in aeronautical engineering more efficient methods for utilizing available power, more efficient and lighter structures, and there are and will continue to be constant improvements. But we need look for no spectacular advances in future such as we have seen in the past. Aeronautical engineering has definitely passed out of the pioneering stage and settled down into a fairly well stabilized art, where slow and orderly development is the order of the day.

It is well that it is so, for experimental construction is costly. No industry can become great until it has become commonplace. The development of air transport demands much capital, and capital is always suspicious of activities whose fundamental engineering problems are not fairly well stabilized, and where no reasonable assurance can be had of a continuation of existing models and of existing manufacturing facilities. It is this very stabilization of types and models which is responsible for the great access of capital to the aviation industry in the past year or two.

You will find, as you look the aircraft manufacturing and operating field over, that the radial air-cooled engine has apparently established itself as the predominating type which is at the core of all air transport development in the heavier than air field. This is the type which is exemplified in the Wright Whirlwind engine which carried Lindbergh to France, and which has driven every plane that has crossed the three

oceans to North, East and West in the past two years. It is the prototype of all the new models which are appearing from all the large number of aircraft engine factories that are springing up over the country.

The field of engine development having reached a condition of reasonable stability, the industry is now free to turn more of its attention to economical manufacturing methods, to mass production, to providing standardized service throughout the country, to simplifying and standardizing existing type models, to lower cost of production and maintenance. We have passed definitely from the spectacular to the commonplace, and as with the railroad, the automobile, the street car, so with airplanes, — when we reach reasonable stability and commonplaceness the road is open for rapid expansion of utilitarian service at reasonable cost, for accession of capital to a new field of faster transport, and just as stabilization in the development of new vehicles to provide means for moving faster and saving time has been the signal for the advent of a new industry, of tremendous importance in the world of affairs, so the present approach to stability in engine development is the signal for approaching stability in aircraft types and the advent of a great new air transport industry, which we see taking form today.

OF GENERAL INTEREST

ENGINEERS IN PUBLIC SERVICE

*By Edward Grossman**

According to tradition, the proper place for engineers in public service is the Public Works Department. This tradition obtains in all countries that have some form of organization to handle the public works. It is customary that an engineering organization like a Public Works Department be in charge of an engineer, although politicians manage to evade even that custom when they can. An extremely rare occurrence is that engineers be appointed to fill municipal positions usually regarded as political "plums."

It is therefore a source of gratification when engineers occupy non-engineering positions in municipal government, as do Messrs. Herbert A. Wilson, the Police Commissioner, and Eugene C. Hultman, the Fire Commissioner. Both are engineers and members of the Society since 1897 and 1898, respectively. Each has worked hard to increase the efficiency of his department, and the results are eminently satisfactory. They have justified their appointments by Mayor Nichols, whose lead in this respect may be followed with profit. To paraphrase O. Henry, many of the public services would not be the worse off for a little engineering. Perhaps in this case Boston once again showed the way, according to her usual habit.

Another source of gratification is the appointment of Col. Charles R. Gow as Postmaster of the Boston Postal District, which is the largest in the country. Colonel Gow is also an engineer and a member of the Society since 1903. It is but fitting that an engineer should occupy a post like the one Colonel Gow won in open competition. Means of communication should always be in charge of an engineer, because the supervision of communications — posts, railways, telephones and telegraphs — is purely engineering work. Positions like that of Minister of Communications in foreign countries and Postmaster-General in this country should be filled by professional engineers. It would be desirable, also, that postmasters of large cities be engineers. There is more to the post office than selling stamps or delivering mail to addressees. Even engineers do not, however, seem to appreciate that communications is an engineering job.

There has been some talk recently about the engineer's duty as a unit of civilized society. His mission in life is not fulfilled when he designs or supervises engineering constructions. He should be called on for general service to the community. The engineer's training is scientific, yet not scholastic, practical, but not superficially so, and

* P. O. Box 9, Grove Hall Station, Boston, Mass.

trained leadership and service is an absolute essential nowadays. Forensic ability or "brass" will not displace it. Leaders nowadays must know what they are talking about, or they will drop out, as many do. Thus we agree that engineering leadership would be desirable. Apparently, all that is necessary to insure obtaining this desirable quality of leadership and service is to appoint engineers to public offices, and we would all be happy ever after.

Not necessarily. There are engineers and engineers. Every one knows, of course, that there are as many different brands of engineers as there are engineering specialties, plus the outsiders who also style themselves engineers. These outsiders are not within the scope of this article; we are concerned only with true engineers. These may, for convenience, be classified in three divisions, according to their aptitudes. The three classes may be called designers, constructors, and administrators. In general, their specialties as a measure for fitness for public service do not count so heavily as do their natural aptitudes.

There is a large class of engineers who are, by natural talent, primarily scientists. Among these we find the designers, the authors of books, the testers of materials, and the educators. They prefer the drafting room, the study, or the laboratory to the construction job or the office. They have the patience to fill a notebook with calculations, or a sheet of paper with drafting artistry, or to adjust weights on a testing machine. The carrying out of their plans is of only academic interest to them. They are the theorists.

Other engineers — probably just as able as the first class — are constructors. Their interest is in the constructive end. They have not that patience required to watch a specimen in the

testing machine or to cover acres of paper with calculations. On the other hand, they are possessed to a marked extent of that patience and determination to carry through the plans of the designers despite obstacles. These are the "practical men."

Then there is the third class, — the administrators. The administrator is a sort of all-around man. He can do the work of either the designer or the constructor, or both, and in addition he has what is known as a "business sense," either native or acquired. Thus, knowing and appreciating the work of the other two classes, he is able to bridge the gulf between the "slide-rule artist" and the "man in the field." He can establish the relation between the wants of a community, a paper full of figures, and a site full of difficulties.

The engineering administrator should be used more by society. His training and skill should be given an opportunity for service in public work. The people as a whole will gain. It is the right of the people to expect that their government will be efficient and will promote their general happiness. It is everywhere being seriously doubted that government by politicians alone is effective or desirable.

The most prominent example of an engineering administrator at the present time is, of course, President Hoover. His record is a matter of common knowledge. From the large enterprises which he administered he graduated to the largest enterprise of all, where, we may be sure, he will reflect credit on engineers. A man of Mr. Hoover's caliber is of international proportions. The world is his stage — admittedly too big a stage for most of us.

The city, the state, or the nation furnishes large enough stages to satisfy the ambitions of most people. Even on

the comparatively limited stage of the community a man can render a full measure of service and display a high type of disinterestedness, leading to bigger things. There are high types of administrators, like the three gentlemen in service at Boston, whose service on the local government may be but a training for greater responsibilities and service.

An engineer in public service of an administrative sort must first of all be a good engineer. Public service should not be the haven for misfits, as is sometimes the case in "practical politics." A good engineer is not a misfit, and because of his record and possibilities he is a desirable man for public office. A case in point is that of Colonel Gow.

The new Postmaster of Boston, since his graduation from Tufts in 1893, has done design and construction on almost every kind of engineering work, including roads and streets, sewerage and water supply, subways, tunnels, and so on. His largest job was very likely the Army Base and Temporary Stores at South Boston, a \$26,000,000 project which Colonel Gow carried through as constructing quartermaster. He has also lectured at the Massachusetts Institute of Technology on "Foundations," and in 1928 was professor of humanics. Besides the purely design and construction work, Colonel Gow put in a great deal of service on various commissions, such as the Metropolitan Water Supply, Planning Board, and the Rapid Transit Commission. He is also interested in various commercial enterprises.

It is fairly obvious that the man who has a record of achievement like Colonel Gow's is a much more desirable element in public service than is a man whose only recommendation is that he is a politician and a "good fellow." On the other hand, it may be argued that engineers are novices in political

life, that they do not appreciate the complex problems of government. This is purely theoretical argument which has been refuted time and time again in practice. The engineer's training is such that he learns quickly by experience. Some engineers, indeed, may not require personal experience in practical politics to know what it is. Many a municipal engineer probably has something cynical to say when politics is mentioned. Nevertheless, politics still rules.

There are engineers who, inspired by a genuine desire for public service as being an honorable work in keeping with their aptitudes, enter politics, where they gain an insight into the machinery of government. The Fire Commissioner, Mr. Hultman, apparently chose this route. After graduating from the Massachusetts Institute of Technology, he served as engineer on industrial enterprises and on railways, besides being a member of various engineering commissions. He gained legislative experience in the State House of Representatives and in the State Senate, where he served on various important committees. During the war he was Fuel Administrator of Massachusetts. Afterwards he served for five years as chairman of the Special Commission on the Necessaries of Life. Mayor Nichols appointed him Fire Commissioner.

Here we have an example of an engineer serving with credit in his own profession, in the Legislature, on special commissions which have only a very remote connection with engineering, and as head of the fire-fighting branch of the city government. It is truly a far cry from lines and grades to putting out fires. But we have still another example.

The Police Commissioner, who was also at one time Building Commissioner, has always maintained an intelligent

interest in public affairs. He appreciated that the engineer ought not to hold himself aloof, being vitally interested in the well-being of his community. A prosperous community will have a busy and happy population. If the men in public service do not have the interests of the community at heart, the community will not be prosperous. Having a knowledge of public affairs and their bearing on community life, Mr. Wilson is able to direct his department so that its efficiency shows a marked increase. The entire department is on its toes, as the saying is, because the engineer at its head is discharging his duties properly, with consequent favorable reaction on his subordinates.

The three examples given in this article show what can be done by engineers. The community is the better off for their being where they are. Engineers

having the proper background and aptitudes can be of great service to their communities. But first they must forget that politics is for politicians. It is not. Politics is for every one, and if an engineer is able to be of help, he should not hesitate.

Engineers must take an intelligent interest in public affairs. They will be drawn into them, anyway; it is therefore well to know the situation thoroughly. It is no stigma for an engineer to be able to talk politics; it is even less of a stigma if he rolls up his sleeves, pitches in and helps. The public wants and appreciates good service in public office. If the engineer can furnish it he should not hold back.

There is no question of the engineer's ability; the question is one of willingness. The engineer can render creditable public service — that is without dispute. Does he want to do it?

PROCEEDINGS OF THE SOCIETY

MINUTES OF MEETINGS

Boston Society of Civil Engineers

APRIL 17, 1929. — The regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall and was called to order by the President, Frank E. Winsor, at 7.15 P.M.

One hundred and twenty-five members and guests were present.

The Secretary reported the names of those elected to membership today by the Board of Government:

Grade of Member: William F. Cummings, *Harold B. Frye, John F. Germaine, *Fritz F. Hampe, Coleman C. McCully, Wallace F. Purrington, Arthur L. Sparrow.

Grade of Junior: Norman W. Brenan, Albert A. Miller, Severin Sabas.

The President presented as speakers of the evening engineers of the Westchester County Park Commission, who described, with the aid of lantern slides, important features of the park and recreational developments of Westchester County, New York.

* Transferred from grade of Junior.

Mr. Leslie G. Holleran, Deputy Chief Engineer, spoke on the "Westchester County, New York, Park and Parkway Development," tracing the growth of the park and parkway system, the financial and administrative phases of the undertaking, considerations of the general layout of the parkways for through traffic, and the landscape features and recreational features provided.

Mr. Arthur G. Hayden, Designing Engineer, spoke on "The Development of Rigid Frame Bridge Construction" as applied particularly to grade-crossing structures."

The adoption of this type of bridge construction with curved girders is considered attractive in appearance, but more particularly an economic type of construction, and a design adapted both to straight and skew bridge crossings.

Following these talks a general discussion was held. Prof. Thomas H. Frost, Massachusetts Institute of Technology, presented lantern slides,—views of experiments showing methods and results of the photo-elastic analysis of stress distribution.

Prof. Charles M. Spofford, M. I. T., Prof. Lewis J. Johnson, Harvard University, and others, spoke on the principles of design of the rigid frame structures.

EVERETT N. HUTCHINS, *Secretary*.

Designers Section

APRIL 10, 1929. — The meeting was called to order at 6.15 P.M. Mr. W. D. Henderson, the Chairman of the Section during the past year, introduced Prof. Hale Sutherland, the new Chairman, who spoke briefly of the policies of the new Administration. Following these remarks he introduced Mr. Clarence R. Day, Assistant Engineer of the Metropolitan District Water Supply Commission.

Mr. Day's subject was "The Design of the Ware River Shaft, Wachusett-Coldbrook Tunnel." He used a large number of slides showing the drawings and models prepared in the process of designing the project.

An unusually large number of questions

were asked by the thirty members and guests who were present.

After a rising vote of thanks to Mr. Day the meeting adjourned at 7.30 P.M.

NORMAN P. RANDLETT, *Clerk*.

Northeastern University Section

APRIL 12, 1929. — The annual meeting of the Northeastern University Section, Boston Society of Civil Engineers, was held April 12, 1929, at 7.30 P.M., in Room 26 of the Huntington Building, Northeastern University, with H. L. Burton presiding.

The minutes of the previous meeting were accepted as read.

The following men were elected to serve for the coming year: Chairman, Fred Hess; Vice-Chairman, J. W. Greenleaf; Clerk, E. Hill; Executive Committee, Oral Calderara, V. L. Stone, H. F. Lord.

The speaker of the evening was Mr. Edwin H. Rogers, Director of Park Engineering, Metropolitan District Commission, who spoke on some present problems and proposed developments in the engineering work of the Metropolitan District. Mr. Rogers outlined the history and growth of the Metropolitan Park Commission. He also described in detail the proposed Charles River Basin Development.

During the discussion which followed, Mr. Rogers described the preparation of the map of the Metropolitan District.

The meeting adjourned at 9 P.M. The attendance was 35.

Previous to the meeting the members had dinner at the Café de Paris.

H. L. BURTON, *Clerk, pro tem*.

APPLICATIONS FOR MEMBERSHIP

[May 20, 1929]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission

and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of fifteen (15) days from the date given.

For Admission

AYER, PERLEY F., Waban, Mass. (Age 36, b. Portland, Me.) Graduate of Tufts College in 1914 with degree of B.S. in structural engineering. Was bridge inspector on Boston & Maine Railroad for eighteen months; 1915-22, with Aberthaw Company on outside construction; 1922 to date, with Boston Sand and Gravel Company as operating manager. Refers to *M. N. Clair, H. A. Gray, W. C. Voss, L. C. Wason.*

HILL, ERNEST SEAMAN, Taunton, Mass. (Age 21, b. Taunton, Mass.) Is a student at Northeastern University, and during co-operative periods has been employed in the Physics Laboratory of the University, also with the Manchester Engineering and Welding Company, at Manchester, N. H. Refers to *W. J. Alcott, Jr., H. B. Alvord, C. O. Baird, J. W. Ingalls.*

O'DONNELL, CHARLES JEROME, Melrose, Mass. (Age 44, b. East Boston, Mass.) Received degree of S.B. in civil engineering from Lawrence Scientific School, with class of 1907, and took a special course in reinforced concrete design at Lowell Institute from 1912-13; 1907-09, was employed by the Charles River Basin Commission as rodman and transitman; 1909-13, was assistant engineer with the Board of Water Supply of New York City, on the

construction of the Catskill Aqueduct; 1913-16, with the park department of the city of Boston as assistant in charge of surveys and construction work; 1916-17, with Massachusetts Highway Commission as resident engineer; 1917 to date, with the Commission on Waterways and Public Lands (later Department of Public Works). Refers to *W. H. Ellis, J. N. Ferguson, E. N. Hutchins, D. J. White.*

SHULITS, SAMUEL, Berlin, Ger. (Age 26, b. Lawrence, Mass.) Graduate of Massachusetts Institute of Technology in 1924. During summers of 1923-24 was resident engineer on road construction with Massachusetts Department of Public Works; October, 1924, to September, 1926, with United States Engineers Office in Buffalo, N. Y., as engineering assistant and junior engineer on tests of hydro-electric units, studies of river hydraulics, etc.; September, 1926, to September, 1928, with I. P. Morris Corporation, Philadelphia, in general engineering work in connection with hydraulic turbine design; September, 1928, to date, John R. Freeman Scholar of B. S. C. E. Refers to *J. B. Babcock, H. K. Barrows, C. M. Spofford, Hale Sutherland.*

For Transfer from Grade of Junior

PENNEY, IRWIN M., Boston, Mass. (Age 27, b. New York City.) Graduate of Rensselaer Institute in 1922, with degree of C.E. From 1922-27, was chief of party in construction department of the New York, New Haven & Hartford Railroad; from June, 1927, to September, 1928, was assistant engineer with C. B. Breed; from September, 1928, to February, 1929, was appraisal engineer with Eastern Massachusetts Street Railway. Refers to *J. B. Babcock, C. B. Breed, C. A. Moore, A. S. Tuttle, F. B. Walker.*

WILBER, KARL HARRY, South Amboy, N. J. (Age 26, b. Trenton, N. J.) Educated in Trenton and South Amboy schools, and a graduate of Northeastern University. Before entering the University worked with city engineer of South Amboy as rodman and transitman on municipal work. During co-operative periods worked for George R. Merrill,

town engineer, Woodbridge, N. J., chief of party until March, 1928; now a junior member of the firm of McMichael & Wilber, C.E. Refers to *H. B. Alword, C. O. Baird, A. O. Bradshaw, W. H. Connor.*

NEW MEMBERS

Members

HARRY CIKINS, 88 Millet Street, Dorchester, Mass.
 FRANK H. MASON, 48 Green Street, Augusta, Me.
 COLEMAN C. McCULLY, 33 Ashmont Street, Dorchester, Mass.
 RUDOLF S. SLAYTER, 40 Queensberry Street, Boston, Mass.
 ARTHUR L. SPARROW, South Orleans, Mass.

Juniors

GEORGE A. BERNAT, 4 Bishop Street, Jamaica Plain, Mass.
 RICHARD P. CROCKETT, 199 St. Botolph Street, Boston, Mass.
 ORAL LEAVITT, 61 Nichols Street, Everett, Mass.
 CARL A. MAGNUSON, 33 Fountain Road, Arlington, Mass.
 JAMES A. MCCARTHY, 63 Dix Street, Dorchester, Mass.

DEATH

JOHN E. L. MONAGHAN . . April 29, 1929

BOOK REVIEW

"Massachusetts Building Laws Manual."
 First edition, 1929; price, \$5. *Massachusetts Building Officials Conference, 80 Boylston Street, Boston.*

This valuable reference work, the first of a series to be published annually, covers the building laws of Massachusetts and of certain cities and towns. Preceding these are two useful lists,—members of the Conference, with addresses and titles, and building officials of the Commonwealth. Part I gives Massachusetts laws relating to the erection, inspection and use of buildings, steam boiler rules, and regulations governing garages, elevators and escalators. In Part II are given synopses of the building and zoning laws of sixty cities and towns in Massachusetts, with supplementary statistical data relating to population, area, valuation, etc., thirty pages being devoted to Boston. The concluding section is a reprinting of "Standard Specifications for Structural Steel for Building Work" of the American Institute of Steel Construction.

That the value of this volume to builders, contractors, engineers, architects and municipal officials received immediate recognition is evidenced by the unusually large number of advertisers,—something over 900. The publishers are to be congratulated on the painstaking care with which the information appears to have been compiled and on the convenient form in which it is presented. It is to be hoped that their request, in the "Foreword," for co-operation in making future editions even more accurate and worth while will meet with a generous response.

BOSTON SOCIETY OF CIVIL ENGINEERS

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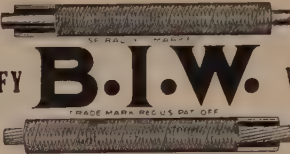
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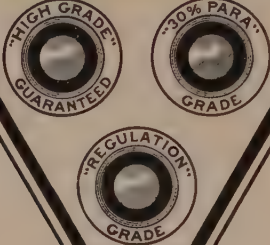
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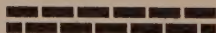
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